Background on the development of the "Global strategy for the *ex situ* conservation of finger millet"

The development of the strategy involved the following main steps:

- The finger millet strategy was initiated in December, 2009 and discussions took place with international, regional and national partners through email discussions whereby a survey questionnaire was finalized for circulation.

- Information and data were gathered using databases such as GENESYS (www.genesys-pgr.org), FAO-WIEWS (http://apps3.fao.org/wiews/wiews.jsp?i_l=EN), SINGER (http://singer.cgiar.org/), EURISCO (http://eurisco.ecpgr.org/) and GBIF); reports and other information resources on the holdings of finger millet genepools and additional inventory of collections.

- Identification of major germplasm collections of finger millet based on information collected above were identified along with Institutes and their respective contact persons to undertake the survey.

- Survey questionnaire was designed in consultation with experts and survey was undertaken to gather information on collections, content and status of conservation in January, 2011 and information was received from 56 countries across Asia, Africa, Europe and Americas.

- After receiving information from the survey, a draft report was finalized and circulated to all the partners for their feedback.

- The consultation meeting was organized on December 23, 2011 to discuss the draft report where participants from India, Kenya, Uganda, Mali, and Senegal participated. Based on their input, the final report was prepared for submission.

**Coordinator:**
Much of the development of the finger millet strategy was coordinated by Dr. P N Mathur (p.mathur@cgiar.org), South Asia Coordinator at Bioversity International in consultation with Dr. Hari D Upadhyaya, Assistant Research Program Director, Grain Legumes and Principal Scientist and Head of Gene Bank at ICRISAT. The strategy is currently coordinated within the Trust by Luigi Guarino.

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# GLOBAL STRATEGY FOR THE *EX SITU* CONSERVATION OF FINGER MILLET AND ITS WILD RELATIVES

**January 2012**

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## DISCLAIMER

This document, developed with the input of a large number of experts, aims to provide a framework for the efficient and effective ex situ conservation of globally important collections of finger millet.

The Global Crop Diversity Trust (the Trust) provided support for this initiative and considers this document to be an important framework for guiding the allocation of its resources. However, the Trust does not take responsibility for the relevance, accuracy or completeness of the information in this document and does not commit to funding any of the priorities identified.

This strategy document (dated January 2012) is expected to continue to evolve and be updated as and when circumstances change or new information becomes available.

In case of specific questions and/or comments, please direct them to the strategy coordinator mentioned in the document.

## BACKGROUND

Conserving the rich diversity of crop varieties and related wild species is essential for providing farmers and plant breeders with raw materials to improve and adapt crops to meet future challenges. The urgent need to conserve endangered genetic resources has been discussed in different international fora. Accordingly, programmes for genetic resources collection and conservation of landraces and crop wild relatives have been promoted by the Food and Agriculture Organization of the United Nations (FAO), through its Commission on Plant Genetic Resources, and by Bioversity International, together with other International Agricultural Research Centres (IARCs) of the Consultative Group for International Agricultural Research (CGIAR). A number of national agricultural research systems (NARS) have also been involved in these international activities and undertakings. In addition, some countries have developed strong national plant genetic resources programmes. Initiatives towards this end have included:

1. Adoption of the International Undertaking on Plant Genetic Resources for Food and Agriculture at the FAO Conference in 1983. The undertaking, adhered to by over 100 countries, was the first comprehensive international agreement dealing with plant genetic resources and was an important milestone in ensuring equity of access to plant genetic resources for food and agriculture.
2. Development of agreed technical standards for the storage, regeneration, documentation and distribution of germplasm samples of crop species.
3. Documentation of existing collections, their coverage and status and the publication of periodic reports and updates on the state of the world's plant genetic resources for food and agriculture.
4. The establishment of and support for a range of regional and crop-specific networks to facilitate a more rational and cooperative approach to the conservation, documentation and use of plant genetic resources.
5. In 1992, the Convention on Biological Diversity (CBD) highlighted the importance of conservation, and in 2002 the Parties to the Convention adopted the

Global Strategy for Plant Conservation, including specific targets for crop diversity conservation. In 2004 the Conference of the Parties to the Convention passed a resolution welcoming the development of the Trust.

6. In 1996, 150 countries adopted the FAO Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. This Plan calls for action to safeguard "as much existing unique and valuable diversity as possible in *ex situ* collections of plant genetic resources for food and agriculture".
7. The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) entered into force in June 2004, and has been ratified by more than 123 countries. The Treaty, which arose from and replaced the International Undertaking, provides a legally binding framework for access and benefit-sharing in relation to plant genetic resources for a defined range of crops.

As a result of these efforts, in the second half of the 20th century and the early 21st, the number and size of plant genetic resources collections all over the world increased significantly. New long-term conservation facilities were built, in which thousands of seed samples were preserved at relatively low cost. Based on figures in the World Information and Early Warning System (WIEWS) on Plant Genetic Resources for Food and Agriculture and country reports, it is estimated that currently about 7.4 million accessions are maintained globally, 1.4 million more than was reported in the first State of the World's Plant Genetic Resources for Food and Agriculture (SoW) report (1996). Various analyses suggest that between 25% and 30% of the total holdings (or 1.9 – 2.2 million accessions) are distinct, with the remainder being duplicates held either in the same or, more frequently, different collections. Germplasm of crops listed under Annex 1 of the ITPGRFA is conserved in more than 1240 genebanks worldwide and comprises a total of about 4.6 million samples. Of these, about 51% are conserved in more than 800 genebanks of the Contracting Parties of the ITPGRFA, and 13% are stored in the collections of the CGIAR Centres. Of the total 7.4 million accessions, national government genebanks conserve about 6.6 million, 45% of which are held in only seven countries, as compared to 12 countries in 1996.

However, important collections of crop diversity face urgent and chronic limited/lack of funding. These shortages can lead to loss of diversity, the very building blocks on which adaptive and productive agriculture depends. In order to address these funding constraints and provide support to national and international genebanks on a sustainable funding support basis, in late 2004, the Global Crop Diversity Trust (Trust) was established. The Trust was founded by the United Nations Food and Agriculture Organisation (FAO) and Bioversity International, as an independent international organization. The Trust is currently hosted in Rome by FAO and is a unique public-private partnership raising funds from individual, corporate and government donors to establish an endowment fund that will provide complete and continuous funding for key crop collections.

In line with the ITPGRFA and the Global Plan of Action for the Conservation and Sustainable Utilization of PGRFA, the Trust's goal is to advance an efficient and sustainable global system of *ex situ* conservation by promoting the rescue, understanding, use and long-term conservation of valuable plant genetic resources.

Achieving the Millennium Development Goals, the priorities for development agreed by all members of the United Nations, will require crop diversity to be effectively conserved, and the Trust directly contributes to three of the goals: to eradicate extreme poverty and hunger (Goal 1); to ensure environmental sustainability (Goal 7); and to develop a global partnership for development (Goal 8). The Trust has commissioned a crop strategy for the *ex situ* conservation of finger millet and its wild relatives to identify gaps in collections and the challenges faced for their conservation and use, in order to support some of these priority activities for agriculture, food and nutrition security.

## 2. OUTLINE OF THE STRATEGY DEVELOPMENT PROCESS

The following procedure was used to develop the strategy:

### 2.1 Focal person for strategy development process

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### 2.2 Strategy development

The project aims to develop, in close consultation with representatives of the relevant institutions and stakeholders, a strategy for the efficient and effective conservation of finger millet genetic resources and to identify priority collections eligible for long-term support from the Global Crop Diversity Trust and their urgent upgrading and capacity building needs. The strategy will promote the rationalization of conservation efforts at national, regional and global levels, e.g. through encouraging partnerships and sharing of facilities and tasks, and will link with the relevant regional conservation strategies.

### 2.3 Expected outputs

- An assessment, in consultation with representatives of the relevant stakeholders, of worldwide/global collections of finger millet and their wild relatives.
- A global ranking of finger millet collections that are 'most important' in terms of size, extent of diversity, holdings of wild relatives and other standards of assessment, carried out in consultation with relevant regional, national and international partners.
- A conservation strategy and recommendations for the long-term management of finger millet collections, facilities and tasks.

### 2.4. Major steps in the development of the strategy

The development of the strategy involved the following main steps:

- Information and data gathered using databases such as GENESYS (www.genesys-pgr.org), FAO-WIEWS (http://apps3.fao.org/wiews/wiews.jsp?i_l=EN), SINGER (http://singer.cgiar.org/), EURISCO (http://eurisco.ecpgr.org/) and GBIF); reports and other information resources on the holdings of finger millet genepools and additional inventory of collections.

- Identification of major germplasm collections of finger millet based on information collected above. Institutes and their respective contact persons identified to undertake the survey.

- Survey questionnaire (**Appendix 1**) designed in consultation with experts and sent to curators of the world's 40 largest finger millet collections in order to gather basic information on the numbers and types of accessions held, the conditions under which they were stored and their accessibility. Survey respondents' contact details are provided in **Appendix 2**.

- Survey information synthesized and gaps identified.

## 3. GLOBAL CONSERVATION STRATEGY FOR FINGER MILLET

Millets are the most important cereals of the semi-arid zones of the world. For millions of people in Africa and Asia they are staple crops. Among millet crops, finger millet figures prominently; it ranks fourth in importance after sorghum, pearl millet and foxtail millet. Finger millet cultivation is more widespread in terms of its geographical adaptation compared to other millets. It has the ability to withstand varied conditions of heat, drought, humidity and tropical weather. It is an important staple in many parts of eastern and southern Africa, as well as in South Asia. The precise estimate of area and production at the global level is not available except for India (presented in Table 1). The global annual planting area of finger millet is estimated at around 4-4.5 million hectares, with a total production of 5 million tons of grains, of which India alone produces about 2.2 million tons and Africa about 2 million tons. The rest comes from other countries in South Asia. The important finger millet growing countries in eastern and southern Africa have been especially the sub-humid regions of Ethiopia, Kenya, Malawi, Tanzania, Uganda, Zaire, Zambia and Zimbabwe. Similarly in South Asia the crop is largely grown in India, Nepal and, to some extent, in Bhutan and Sri Lanka. Finger millet is reported to be grown in both China and Japan to a limited extent.

The grain of finger millet has a fine aroma when cooked or roasted and is known to have many health-promoting qualities. The grain can be stored for years without insect damage, which makes it a particularly valuable crop for famine-prone areas. The crop provides food grain as well as straw which is valued animal feed, especially in the rainfed areas. Among the major food grains, finger millet is one of the most nutritious crops for protein, minerals (calcium and iron) and amino acids (methionine, an amino acid lacking in the diets of hundreds of millions of the poor who live on starchy foods such as cassava, plantain, polished rice, and maize meal); and provides 8-10 times more calcium than wheat or rice. Finger millet carbohydrates are reported to have the unique property of slower digestibility and can be regarded as food for

long sustenance. The excellent malting qualities have added to the uniqueness of the grain in expanding its utility range in food processing and value addition. Finally, the crop is productive in a wide range of environments and growing conditions, from southern Karnataka state in India to the foothills of the Himalayas in Nepal, and throughout the middle-elevation areas of Eastern and Southern Africa.

In spite of all these advantages, finger millet has been a neglected crop, both at national as well as global levels. The crop is little known in many countries in Europe, or South and North America. In recent years, the production of this neglected crop has been declining rapidly, airing fears that finger millet grain may become a rare commodity.

**Table 1: Area, production and productivity of finger millet in India**

| State | 2002-07 | | | 2008-09 | | |
|---|---|---|---|---|---|---|
| | **Area (000 hectares)** | **Production (000 tons)** | **Average productivity (Kg/ha)** | **Area (000 hectares)** | **Production (000 tons)** | **Average productivity (Kg/hectare)** |
| Andhra Pradesh | 69 | 82 | 1192 | 50 | 52 | 1040 |
| Bihar | 16 | 12 | 733 | 11 | 9 | 816 |
| Gujarat | 22 | 20 | 891 | 19 | 20 | 1053 |
| Jharkhand | 16 | 11 | 670 | 12 | 9 | 702 |
| Karnataka | 840 | 1223 | 1455 | 841 | 1394 | 1658 |
| Maharashtra | 142 | 139 | 980 | 126 | 125 | 992 |
| Orissa | 71 | 42 | 585 | 65 | 41 | 624 |
| Sikkim | 4 | 4 | 890 | 4 | 4 | 886 |
| Tamil Nadu | 111 | 169 | 1529 | 90 | 170 | 1887 |
| Uttarakhand | 147 | 176 | 1195 | 135 | 193 | 1430 |
| Uttar Pradesh | 1 | 1 | 1370 | 1 | 1 | 1333 |
| West Bengal | 13 | 15 | 1175 | 13 | 15 | 1157 |
| Others | 17 | 8 | 471 | 14 | 7 | 500 |
| **Total** | **1469** | **1902** | **1295 - National average** | **1381** | **2040** | **1477 - National average** |

## 4. ORIGIN AND TAXONOMY

Finger millet [*Eleusine coracana* (L.) Gaertn] subspecies *coracana* belongs to the family Poeceae. **Botanical name:** *Eleusine coracana* (L.) Gaertn (Hilu and de Wet 1976).

**Common name:** Various common names of finger millet in different countries have been reported and are given below:

Afrikaans and Dutch: *Vogel Gierst*
Arabic: *Taibbon*
Boutu: *Bale*
English: *Finger millet*; *African millet; Koracan*
French: *Petit millet*, *eleusine cultivee, Coracan, Koracan*
German: *Fingerhivse* (horse)
Swahili: *Wimbi*, *ulezi*
Ethiopia: *Dapussa, Tokusa, Bavankiya*
India: *Ragi*
Kenya: *Limbi, mugumbi*
Malawi: *Hawere, lipoke, usanje, khawke, malesi, mulirubi, lupodo, mawe*
Nepal: *Koddo*
Sudan: *Tailabon (Arabic), ceyut (Bari)*
Tanzania: *Mwirubi, mbege*
Uganda: *Bulo*
Zambia: *kambale, lupoke, mawele, majolothi, awale, bule*
Zimbabwe: *Rapoka, zviyo, niera, mazhovole, rukweza, uphoka, poha*

### 4.1 Morphological description

Finger millet is a tufted annual crop, growing to a height of 30–150 cm and maturing in 75–160 days. Leaves are narrow, grass-like and capable of producing many tillers and nodal branches. The panicle consists of a group of digitally arranged spikes often referred to as fingers. The spikelets are made up of 4–10 florets arranged serially on the finger. All florets are perfect flowers with the exception of the terminal ones which may sometimes be infertile. The grain is oblong to round and oval, reddish brown in colour with the grains' surface finely corrugated.

Finger millet grows best in an environment with medium rainfall (29–429 cm) and an annual temperature range of 11 to 27°C, and is reported to tolerate a soil pH of 5.0–8.2 (Duke 1978, 1979). Areas with low precipitation and low relative humidity during seed ripening and maturation are best for regeneration. Easy to grow, it succeeds in ordinary garden soil in a sunny position. Typically a tropical, rainfed crop, it is one of the best suited for dry farming. Finger millet is very adaptable and thrives at higher elevations than most other tropical cereals.

### 4.2 Origin and Domestication

The cultivated *E. coracana* is a tetraploid (2n=4X=36) and exhibits morphological similarity to both *E. indica* (2n=18) and *E. Africana* (2n=36). It was earlier thought that cultivated *E. coracana* originated from *E. indica*, of which the distribution is quite wide, from Africa eastwards to Java. The cytological evidence indicates that *E. indica* has contributed one of the genomes (AA) to the cultivated *E. coracana* (AABB) which is an allotetraploid. The species *E. africana* (2n=36), which is also a tetraploid, exhibits great similarity in morphological feature with *E. coracana;* they are genetically related and gene flow occurs between them in nature, suggesting *E. coracana* possibly originated from *E. africana* through selection and further mutation towards larger grains (Channaveeraiah and Hiremath, 1974; Hilu and de Wet, 1976).

The archaeological findings of finger millet from Ethiopia date to about the third millennium BC (Hilu *et.al* 1979). The two distinct races of finger millet recognized are the African highlands race and Afro-asiatic lowland race. The African highlands race is considered to be derived from *E. africana* under cultivation and this gave rise to the African lowland race which later migrated to India and developed as the Afro-Asiatic lowland race (Mehra, 1962; Purseglove, 1976). This migration of finger millet to the Indian sub-continent is likely to have occurred around 3000 BC. Studies of the patterns of variability in African and Asian finger millets has by and large indicated relatively larger diversity in African germplasm compared to Indian collections, lending support to the view that Africa could be the primary centre of origin. The long history of cultivation in the Indian subcontinent for more than 5000 years since then, accompanied by human selection, has resulted in the generation of large diversity in landraces and local cultivars in India. Close study of various characters in Indian germplasm has revealed that for economically important characters such as finger length, finger width, finger number, grain yield, ear weight, total biomass and leaf number, the Indian germplasm possesses large variability indicating India as the secondary centre of diversity (Naik *et. al*, 1993).

### 4.3 The *Eleusine* genepool

It is now evident that cultivated finger millet is highly variable within its primary centre of origin in Africa and secondary centre in Indian sub-continent. Both wild finger millet (*Eleusine coracana* subspecies *africana*) and the cultivated finger millet (*Eleusine coracana* subspecies *coracana*) are important from the point of view of germplasm collection and conservation and form the primary genepool. Wild finger millet (subspecies *africana*) is native to Africa but has migrated to several warmer parts of Asia and America. Natural hybridization between wild and cultivated finger millets has resulted in hybrid derivatives and in companion weeds of the crop in Africa. This no doubt has led to the generation of new diversity of intermediate forms. The weedy and wild forms are restricted to the closely related annual species.

For the sake of taxonomic interest, the cultivated finger millets have been divided into four races and several sub-races (see Table 2) which are mainly based on the inflorescence morphology (Prasada Rao *et.al*, 1993). Within these races there are hundreds of varieties, some of which are as follows: 'AKP-2' fast-growing form is green throughout, with incurved panicle, maturing in 85–90 days. 'Candlestick', heads are borne on tall stalks and are shaped like candlesticks. The plants tiller heavily. 'Dragon's Claw' seeds are smaller than some millets and are difficult to thresh.

The diploid wild species *E. indica, E. floccifolia* and *E. tristachya* form the secondary genepool and the tertiary genepool comprises species *E. intermedia, E. gaegeri, E. kigeziensis, E. multiflora* and *E. semisterlis (E. compressa*).

**Table 2: Cultivated finger millet genepool races and sub-races**

| Species | Sub- | Race | Salient inflorescence features |
|---|---|---|---|

| | species | | |
|---|---|---|---|
| *E. Coracana* | *Coracana* | *Elongata* (three sub-races are recognized: *laxa, reclusa* and *sparsa*) | Long slender inflorescence, branches 10-24 cm long, digitately arranged spikes spreading and curved outward at maturity. |
| | | *Plana* (three sub-races are recognized: *seriata, confundere* and *grandigluma*) | Large spikelet (8-15 mm long) arranged in two more or less even rows along the rachis giving the inflorescence branch a flat ribbon-like appearance. |
| | | *Compacta* | Spikelets are composed of 9 or more florets and incurved at the tip to form a large fist-like inflorescence. |
| | | *Vulgaris* (has four sub-races;*liliaceae, stellata, incurvata* and *digitata* are recognized based on minor differences) | Most common type with 4-8 florets in a spikelet giving an appearance of semi-compactness with tip of finger incurved at maturity. |

## 5. OVERVIEW OF FINGER MILLET COLLECTIONS

The global in-trust collections managed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India comprises a total of 5957 accessions of which 105 are of wild species, 5665 landraces, 137 of improved cultivars and 50 breeding/research materials. Most of these collections are of exotic or non-Indian origin (4585 accessions). In addition to ICRISAT, the Agricultural Research Station of the USDA in Griffin, Georgia maintains 766 accessions of which 17 are of wild relatives (*E. floccifolia*, *E. indica*, *E. jaegeri*, *E. multiflora* and *E. tristachya*). These accessions belong to 11 countries which include: Ethiopia (2), India (646), Kenya (3), Nepal (4), Pakistan (2), South Africa (1), Tanzania (1), Uganda (54), Zaire (3), Zambia (1) and Zimbabwe (2). Among the National collections, the largest collection was recorded from the Indian genebank (National Bureau of Plant Genetic Resources), based at New Delhi which maintains 10507 accessions of finger millet under long-term conservation. Most of these collections are indigenous in nature with only 117 accessions of exotic origin. These Indian collections also include 6 wild relatives, 154 advanced improved varieties and 64 breeding/research material. Most of the Indian collections (58 per cent) are also being maintained as medium-term storage at the All India Small Millets Improvement Programme (AISMIP) at Bangalore, which is also being used as a working collection and meet the demands of national researchers. . The other countries holding large collections from South Asia include: Nepal (877), Sri Lanka (393) and Bhutan (84). Among African countries the largest collections were reported from genebanks based in Kenya (1902), Zimbabwe (1158), Uganda (1155), Zambia (497), Tanzania (293), Malawi (145), Eritrea (120), Burundi (113), Ethiopia (71), Nigeria (20) and South Africa (17). Other countries reported to conserve finger millet collections are China (300), Russian Federation (110) and Vietnam (52). The details of these collections are presented in Table 3 for major collections and Table 4 for other minor collections.

A total of 25707 finger millet accessions were recorded in various sources. Most of them were collected by or are maintained in the ICRISAT genebank (2222 accessions) or the collecting missions supported by Bioversity International (most of these accessions have also become part of ICRISAT and USDA collections). Landraces represent the largest proportion of accessions of finger millet germplasm conserved in genebanks worldwide. Only 5% are wild relatives (1274), fewer than 2% are advanced improved varieties (347), fewer than 0.8% are breeding/research materials (200) and 0.6% are of unknown description (154).

Some progress has been made in the recent past in mapping the finger millet diversity collected worldwide. The global database indicates that georeference data have been assigned to 3229 accessions. No such information is available for any of the national collections. It is therefore, important that support and guidelines be provided to other finger millet collection holders for georeferencing their respective collections, followed by mapping of diversity and identifying gaps in their collections. Based on the georeference information from the global database, the distribution pattern of these accessions is shown in Figure 1.

**Table 3: Finger millet germplasm holdings including accessions originating in the country (indigenous) as well as introduced from other countries (exotic) and their categories ( landraces, advanced/improved varieties, breeding and/or research materials).**

| Country | Total No. of Accessions | Origin of germplasm | | Landraces | Wild relatives | Advanced/ Improved varieties | Breeding/ Research materials | Others | Source of information |
|---|---|---|---|---|---|---|---|---|---|
| | | Indigenous | Exotic | | | | | | |
| Bhutan | 84 | 84 | | 84 | | | | | Survey |
| Burundi | 113 | 113 | | 113 | | | | | Survey |
| China | 300 | 255 | 45 | 300 | | | | | Survey |
| Eritrea | 120 | 120 | | 120 | - | | | | Survey |
| Ethiopia | 71 | | | 67 | 4 | | | | GENESYS |
| India | 10507 | 10549 | 117 | 10180 | 6 | 154 | 64 | 103 | Survey |
| Kenya | 2920 | 1899 | 1021 | 1813 | 1071 | | 36 | | Survey |
| Malawi | 145 | 145 | | 145 | | | | | Survey |
| Nepal | 877 | 877 | | 877 | | | | | Survey |
| Nigeria | 20 | | | 19 | 1 | | | | GENESYS |
| Russian Federation | 110 | | | 51 | - | 9 | 50 | - | Survey |
| South Africa | 17 | 17 | | 17 | | | | | Survey |
| Sri Lanka | 393 | 335 | 58 | 344 | 3 | 46 | | | Survey |
| Tanzania | 293 | 283 | | 283 | 10 | | | | Survey |
| Uganda | 1155 | | | 1155 | | | | | Survey |
| USA | 766 | | 766 | 719 | 17 | | | 30 | Survey |
| Vietnam | 52 | 52 | | 52 | | | | | Survey |
| Zambia | 497 | 497 | | 497 | - | | | | Survey |
| Zimbabwe | 1158 | | | 1157 | 1 | | | | Survey |
| GLOBAL (ICRISAT) | 5957 | 1372 | 4585 | 5665 | 105 | 137 | 50 | | Survey |
| **Total** | **25555** | **16598** | **6592** | **23658** | **1218** | **346** | **200** | **133** | |

**Table 4: Minor collections of finger millet germplasm by country, including accessions originating in the country (indigenous), as well as introduced from other countries (exotic) and their categories (landraces, advanced/improved varieties, breeding and/or research materials)**

| Country | Total No. of Accessions | Origin of germplasm | | Landraces | Wild relatives | Advanced/ Improved varieties | Breeding/ Research materials | Others | Source of information |
|---|---|---|---|---|---|---|---|---|---|
| | | Indigenous | Exotic | | | | | | |
| Argentina | 1 | | | | 1 | | | | GENESYS |
| Australia | 13 | | 13 | 11 | 2 | | | | Survey |
| Austria | 10 | | 10 | 10 | - | | | | Survey |
| Azerbaijan | 1 | | | | 1 | | | | GENESYS |
| Belgium | 4 | | | | 4 | | | | GENESYS |
| Bolivia | 1 | | | | 1 | | | | GENESYS |
| Botswana | 1 | | | | 1 | | | | GENESYS |
| Brazil | 2 | | | | 2 | | | | GENESYS |
| Burkina Faso | 1 | | | | 1 | | | | GENESYS |
| Cameroon | 8 | | | 8 | | | | | GENESYS |
| Central African Republic | 4 | | | 1 | 3 | | | | GENESYS |
| Congo | 4 | | | | 4 | | | | GENESYS |
| Czech Republic | 1 | | | | 1 | | | | GENESYS |
| Denmark | 1 | | | | 1 | | | | GENESYS |
| Ecuador | 2 | | | | 2 | | | | GENESYS |
| Germany | 22 | | 22 | | 2 | 1 | - | 19 | Survey |
| Hungary | 15 | | | 11 | 4 | | | | Survey |
| Indonesia | 1 | | | | 1 | | | | GENESYS |
| Italy | 7 | | | | 7 | | | | GENESYS |
| Lebanon | 2 | | | | 2 | | | | GENESYS |
| Maldives | 4 | | | | 4 | | | | GENESYS |
| Mexico | 3 | | | 2 | 1 | | | | GENESYS |
| Mozambique | 12 | 12 | | 12 | | | | | Survey |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Niger | 1 | | | | 1 | | | | GENESYS |
| Oman | 1 | | | | 1 | | | | GENESYS |
| Pakistan | 4 | | | 4 | | | | | GENESYS |
| Peru | 2 | | | | 2 | | | | GENESYS |
| Puerto Rico | 1 | | | 1 | | | | | GENESYS |
| Romania | 4 | | | 3 | 1 | | | | GENESYS |
| Senegal | 5 | | | 5 | | | | | GENESYS |
| Sweden | 1 | | | | 1 | | | | GENESYS |
| Tunisia | 1 | | | 1 | | | | | GENESYS |
| Ukraine | 1 | | | | | | | 1 | GENESYS |
| United Kingdom, Kew | 1 | | 1 | - | - | | | 1 | Survey |
| Uruguay | 1 | | | | 1 | | | | GENESYS |
| Zaire | 9 | | | 5 | 4 | | | | GENESYS |
| **Total** | **152** | **31** | **27** | **74** | **56** | **1** | | **21** | |

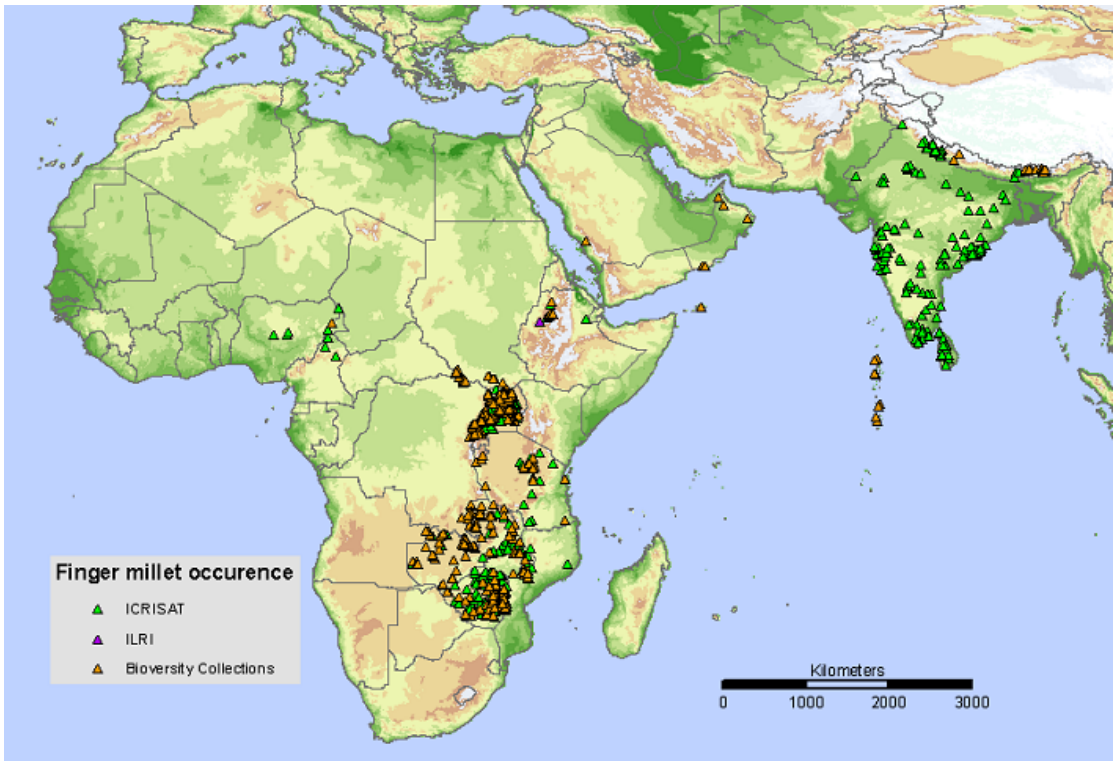


**Figure 1: Mapping of finger millet accessions based on information available from the global database**

GENESYS is a new global PGR database portal, developed by Bioversity International with financial support from the Trust and ITPGRFA. GENESYS currently provides access to information for 2.5 million germplasm accessions including information for 7516 accessions belonging to 8 species of the genus *Eleusine*. Of these accessions, 2232 accessions belonging to 5 *Eleusine* species have georeference information (Table 5) and hence they can be mapped. Mapping of these collections is shown in Figure 2.

**Table 5: Information available in GENESYS for *Eleusine* species accessions**

| Sl. No. | Genus/species | Total no. of accessions | Total no. of georeferenced accessions |
|---|---|---|---|
| **1** | *Eleusine coracana* | 7448 | 2223 |
| **2** | *Eleusine floccifolia* | 3 | |
| **3** | *Eleusine indica* | 43 | 4 |
| **4** | *Eleusine jaegeri* | 1 | |
| **5** | *Eleusine kigeziensis* | 6 | 3 |
| **6** | *Eleusine multiflora* | 1 | |
| **7** | *Eleusine sp.* | 3 | 1 |
| **8** | *Eleusine tristachya* | 11 | 1 |
| | **Grand Total** | **7516** | **2232** |

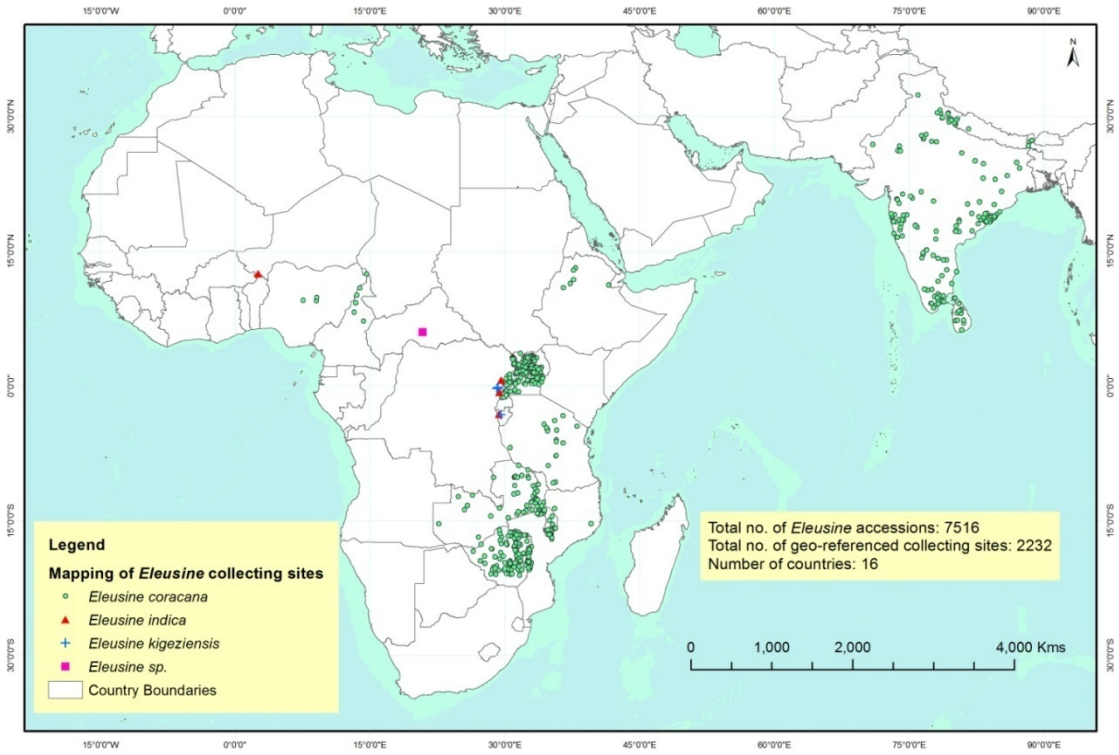


**Figure 2: Mapping of *Eleusine* accessions based on information from GENESYS**

## 6. STATUS OF CHARACTERIZATION AND EVALUATION

Characterization and evaluation are prerequisites for the efficient utilization of conserved germplasm. From the survey questionnaire (Appendix 1) it appears that although a modest number of accessions have been assembled and maintained in many countries, systematic characterization and evaluation activities are not sufficient. One reason provided by most genebanks is lack of adequate manpower and resources. Evaluation activities, especially in Africa, have been fewer than hoped.

In India, at the National Active Germplasm Site (NAGS), characterization and evaluation of accessions is carried out to identify and document finger millet germplasm. More than 70% of the accessions have been evaluated and characterized for important characters using Bioversity descriptors. A catalogue for 4000 finger millet accessions has been created with information on 37 descriptors (Ramakrishna *et al*, 1996).

Similarly, at ICRISAT, Patancheru, the entire collection has been characterized for 8 qualitative and 14 quantitative characters. Based on plant pigmentation, the germplasm accessions were classified into green (non-pigmented) or pigmented. More than 50% of the green plant accessions were from Kenya, Nepal, Zambia and Zimbabwe. Finger millet normally has three types of growth habit – decumbent, erect and prostrate. In the ICRISAT collection, only two types (decumbent and erect) were present, with dominance of erect types (93%), while the prostrate types were completely absent. The range varied from 50–120 cm (Zimbabwe) to 85–130 cm (Ethiopia, Malawi, Uganda and Zaire) indicating that the dwarf plant (up to 75 cm)

accessions occurred in Zimbabwe with greater frequency (7%) than in the entire collection (5%) from Southern and Eastern Africa. The range in flowering varied from 62–96 days in the accessions from Kenya to 73–81 days in accessions from Tanzania and Zaire, indicating that early flowering accessions occurred in Kenya and late flowering accessions were found in Tanzania and Zaire.

The mean inflorescence length ranged from 88 (Malawi and Zambia) to 104 mm (Ethiopia). The mean of inflorescence width ranged from 55 mm (Zaire) to 103 mm (Nepal). The range varied from 40–215 mm in the accessions from Kenya, Zimbabwe and unknown origin to 60–180 mm in accessions from Nepal, Ethiopia and Tanzania, indicating that narrowest inflorescence width accessions were found in Kenya, Zimbabwe and unknown origin, while the broadest width accessions were found in Nepal, Ethiopia and Tanzania. Similarly the average panicle exsertion ranged from 75 mm (Zimbabwe) to 110 mm (Uganda). However, the range varied from 0 (Kenya, Nepal, Zimbabwe and unknown origin) to 80 mm in accessions from Tanzania and Zaire, indicating that accessions with no exsertion occurred in Kenya, Nepal and Zimbabwe and maximum exsertion accessions were found in Tanzania and Zaire. A wide range of grain colours (dark brown, light brown, *ragi* brown, reddish brown and white) were observed in finger millet germplasm collections introduced from Southern and Eastern Africa. The majority of the accessions were light-brown (57%), followed by reddish-brown (22%), dark-brown (10%), *ragi* brown (8%) and white (2%).

Based on the multilocational characterization and evaluation trials in India and the information contained in the publication entitled "Finger millet [*Eleusine coracana* (L.) Gaertn.] core germplasm for utilization in crop improvement" by the AICSMIP (Gowda *et al.* 2005), promising accessions have been identified for various agronomic traits (plant height, productive tillers, finger number, finger length, days to flowering, 1000 grain weight, grain yield, harvest index, and straw weight), blast resistance, high grain calcium and high grain protein have been identified. It was also reported that some of the landraces have wide adaptation, based on their performance during multilocational trials, and are therefore very useful in climate change adaptation and for use in crop improvement programmes.

Bioversity International, in consultation with various partners, has developed a comprehensive list of descriptors for finger millet (Bioversity, 2010). This strategic set of descriptors, together with passport data, are an integral part of the information available through the global accession level information portal GENESYS, developed by Bioversity International with the support of the Global Crop Diversity Trust. It will facilitate access to and utilization of finger millet accessions held in genebanks and does not preclude the addition of further descriptors, should data subsequently become available. The list includes:

1. Plant height
2. Plant pigmentation
3. Productive tillers
4. Days to flowering
5. Ear shape (droopy, open, semi-compact, compact and fist-like)
6. Finger branching

7. Finger length
8. Number of grains per spikelet (low, intermediate and high)
9. Grain colour (white, light-brown, copper-brown, purple-brown)
10. Green fodder yield
11. Ginger number
12. Days to maturity
13. 1000-grain weight [g]
14. Grain yield per plant [g]
15. Grain protein content [DW %]
16. Calcium content [DW %].

## 7. FORMATION OF CORE SUB-SETS

The concept of forming core sub-sets from large collections of germplasm has emerged as effective for enhancing the utility of conserved germplasm. From the survey questionnaire and personal enquiry we realized that there are at least two core sub-sets formed and evaluated in India. The first set was developed during 2002 at the National Active Germplasm Site (NAGS) based at AICSMIP, Bangalore with 551 accessions. The NAGS core collection was formed from the entire collection maintained at AISMIP (nearly 6000 accessions), representing the diversity available in South Asian and African collections. The large database that was available on origin, geographical distribution, as well as evaluation and characterization data, has been used in forming the core set. This core set was evaluated during 2003 at four locations differing in climate and soil. Comparison of diversity between core and total collection broadly indicated that this core set harbours the diversity available in the entire collection. A comprehensive catalogue on core collection content has been published (Jayarame Gowda *et al*, 2005). Recently a mini core set with 110 accessions has been formed from the core developed with 551 accessions and is being used for intensive evaluation especially for nutritional and grain quality parameters. The scientist at ICRISAT (Upadhyaya *et. al*, 2006) has also developed core (622 accessions) and mini core (80 accessions) collections based on data recorded for 14 quantitative traits. Using the mini-core approach, several trait-specific germplasm samples with resistance to biotic and abiotic stresses and nutritional traits have been identified.

## 8. OVERVIEW OF VARIABILITY PATTERN IN AFRICAN AND INDIAN GERMPLASM

Based on the information available from Africa and Indian germplasm collections of finger millet, it is now widely recognized that the highlands of Africa, especially Ethiopia/Uganda, are the primary centre of origin and the Indian sub-continent is the secondary centre. The crop has been in cultivation on both continents for more than 5000 years, but separated. This spatial isolation led to the emergence of two distinctly different genepools both genetically and morphologically.

There have been very few systematic studies comparing the diversity found in the African and Indian collections. In one such study carried out by Naik *et al* (1993), variability patterns in 120 Indian accessions representing 30 Indian states and 105

accessions representing seven African countries were assessed for five qualitative and 24 quantitative characters. The study reported that a higher proportion of Indian accessions were pigmented compared to those from Africa. By and large African germplasm presented much larger variation for inflorescence colour compared to Indian germplasm. For inflorescence characters too, the African and Indian germplasm differs, with the majority of Indian accessions having semi-compact or compact ears (race *vulgaris*) and African accessions showing diverse ear types ranging from open to fist shaped (race *plana* and *compacta*). African accessions also exhibited higher intensity of finger branching compared to Indian accessions.

For quantitative characters the African and Indian accessions also appeared distinctly different. The Indian germplasm exhibited higher variability for characters associated with grain and stover yield. This included characters such as finger length, finger width, grain yield potential, ear weight, total biomass and stover weight and leaf number. For these characters the mean values in Indian accessions were higher than in African accessions. On the other hand African germplasm exhibited large variation, with mean values skewing towards late maturity, tallness, stout plant stature, long broad flag leaf, long narrow finger, higher number of spikelets, more florets per spikelet, small and long glumes, poor threshability and lower harvest index. There are indications that wild and weedy ancestor *E. africana*, which has introgressed fairly easily with cultivated finger millet, has contributed to the cultivated genepool diversity generated in Africa. Furthermore, the African germplasm appears to possess a higher level of resistance to blast (the most devastating disease of finger millet).

Jayarame Gowda *et al* (2005) carried out an elaborate multilocational evaluation study of the NAGS core germplasm set consisting of 551 accessions representing many countries in Africa and South Asia, more or less covering the major finger millet growing areas in the world. This core set had a majority of accessions from two main geographical regions, Africa (primary centre of diversity) and India (secondary centre of diversity). The comparison of variability between these two regions for 16 qualitative and 22 quantitative descriptors revealed that the amount of variability and diversity present in these distinct regions is high and more or less comparable. This substantiates the fact that collection and conservation efforts in both the regions are equally important.

## 9. UTILIZATION

Identification of useful germplasm for crop improvement is the first step in encouraging utilization. From the survey questionnaire it was difficult to obtain a good comparison on utilization activities in various genebanks, especially in Africa. However, in India, under the National Agriculture System, modest efforts have been going on in the last three decades to exploit finger millet germplasm with useful genes for crop improvement.

To promote utilization, efforts have initially focused on identifying the most useful germplasm accessions in the ongoing crop improvement efforts. Accessions possessing desirable attributes such as early vigour, large panicle, high finger number, high grain density, bold seeds and high test weight have been identified, especially in the African collections. Over 100 accessions of finger millet are found to be resistant

to blast and available for use in breeding. There are accessions available with special traits like low leaf area, high photosynthetic efficiency, high water use efficiency, drought tolerance, etc.

Systematic finger millet improvement work has been ongoing in India since the early 1950s. The most significant aspect of finger millet improvement in India has been the use of African germplasm in hybridization programmes (Gowda *et al*, 1986). The intercrossing of African germplasm with the Indian germplasm has revealed a potential for using the two isolated germplasm pools. These efforts resulted in the generation of breeding materials and subsequent selection resulted in the development and release of a series of highly productive varieties, more recently combined with blast resistance for cultivation. More than a dozen varieties of finger millet have been released at the national level (PR202, PS110, RAU8, KM13, PES400, VL149, VL146, GPU28, GPU45, GPU26, GPU66, GPU67, VR708, BM9-1) along with other varieties released for cultivation at the state level (AKP2, RATNAGARI, Kalyani, Gujarat Nagali 2, Gujarat Nagali 3, MR1, MR6, L5, HR911, Indaf5, Indaf8, Chilka, Bhariaba, Subra, Co12, C013, Co14, VL315, VL324, PRM 1, PRM2, etc.).

In the finger millet breeding programme in India, blast resistance is one of the priority objectives and many stable sources of resistance have been identified and used. Many sources of resistance have come from African germplasm. At ICRISAT several initiatives are underway to enhance the use of finger millet germplasm through deployment of core and mini-core approaches and identification of trait-specific germplasm.

## 10. GEOGRAPHICAL DISTRIBUTION OF *ELEUSINE* SPECIES AND THEIR GAPS IN WORLD COLLECTIONS

A study was undertaken by CIAT, IRRI and Bioversity International with support from the Global Crop Diversity Trust and the World Bank, using datasets of herbarium collections as well as the germplasm collections available from GBIF and SINGER and the climate database available at WorldClim to understand the spatial distribution of accession origins and thus evaluate gaps in world collections.

Results of the gap analysis studies (Ramirez M *et al,* 2009*)* for finger millet are available on the CIAT website (http://gisweb.ciat.cgiar.org/GapAnalysis/?p=265). As shown in Table 6, almost all the records used have been obtained from herbarium samples, except for three records from genebank collections, for primary, secondary and tertiary wild relatives of finger millet. The herbarium records show the presence of these wild species in Americas in addition to their presence in Africa, however, no finger millet cultivation or germplasm accessions were recorded in any of the genebanks in the Americas. The analysis also shows that none of the genebank collections from Africa and Asia have collections of these wild species and hence priority should be given to collecting these wild relatives of finger millet.

Data for gap analysis was found for six wild species (*E. africana*, *E. indica*, *E. jaegeri*, *E. kigeziensis*, *E. multiflora* and E. *tristachya*). The different taxa are classified as follows, according to their closeness to the cultivated species *E. coracana,* using the Maxted and Kell (2009) approach:

| Primary wild relatives | Secondary wild relatives | Tertiary wild relatives |
|---|---|---|
| *E. africana* | *E. tristachya* | *E. jaegeri* |
| *E. indica* | *E. floccifolia* | *E. multiflora* |
| *E. kigeziensis* | *E. intermedia* | *E. compressa* |

Species' taxonomy was reviewed using Maxted and Kell (2009) in the first stage, the GRIN taxonomical and the Royal Botanic Gardens, Kew taxonomy databases. After cross-checking and correcting both synonyms and orthography of the species' names, a thorough georeferencing process was carried out to obtain a spatially explicit database containing as many records as possible for each species. After this, records outside continental boundaries were deleted and a final dataset was produced for analysis.

The analysis dataset contained 73 observations (excluding *E. indica,* a noxious weed, for which the number of samples was 383), with 70 (96%) being herbarium specimens and 3 (4%) being genebank accessions. The average number of total samples per taxon was 15 (standard deviation of 21), which indicates that the information is quite poor in all taxa; however, *E. tristachya* presented a relatively high number of data points, with 52 herbarium specimens.

The gap analysis of the *Eleusine* genepool found that all six taxa are either under-represented or not represented at all in genebank holdings, including the weed *E. indica*, which is not regarded as a high priority species as it is distributed along with the cultivated species *E. coracana* as a weed. Four of these taxa have either ten or fewer than ten observations in total, which indicates the urgent need for a collecting mission (or the need for more readily available genebank and herbarium data). Potential sampling zones for *E. tristachya* and *E. indica* were, however, mapped out, and for those species with no potential distributions herbarium samples were used as the basis for defining likely sampling zones in the future.

East Africa is considered as the centre of diversity of the genus. Species from this genus are distributed in the tropical and subtropical parts of Africa, Asia and South America. Table 6 shows the number of records (herbarium, germplasm, total) used per species for the *Eleusine* genepool gap analysis. The outcome of these studies is presented in Figures 3 and 4.

**Table 6: Data used in the *Eleusine* genepool gap analysis**

| Species | Genebank accessions | Herbarium samples | Total |
|---|---|---|---|
| *Eleusine africana* | 0 | 6 | 6 |
| *Eleusine indica* | 0 | 383 | 383 |
| *Eleusine jaegeri* | 0 | 10 | 10 |
| *Eleusine kigeziensis* | 3 | 0 | 3 |
| *Eleusine multiflora* | 0 | 2 | 2 |
| *Eleusine tristachya* | 0 | 52 | 52 |

Based on the analysis, all these species have been identified as high priority for conservation.

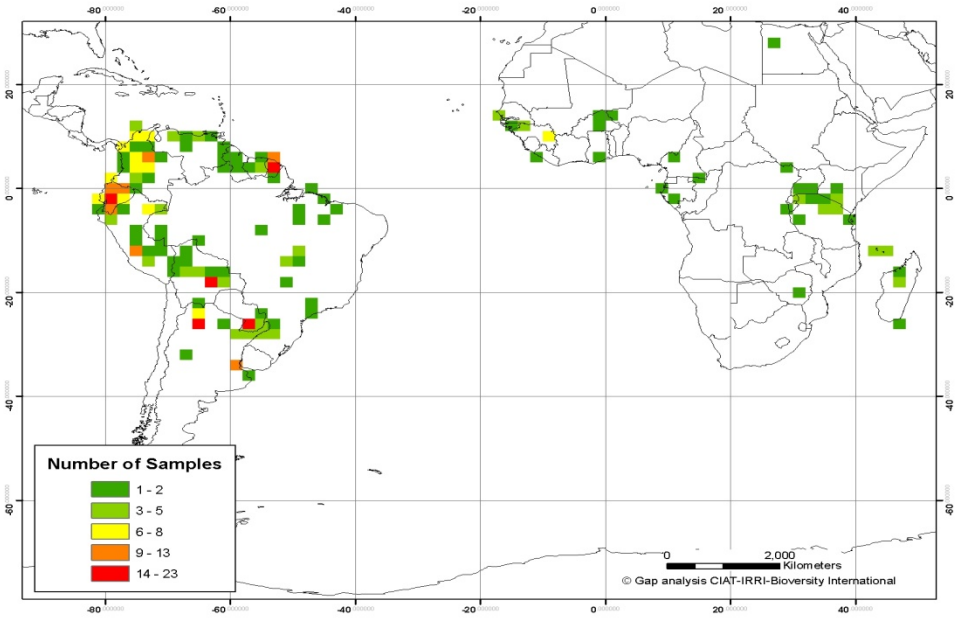


**Figure 3: Potential sampling index for *Eleusine* species (http://gisweb.ciat.cgiar.org/GapAnalysis/)**

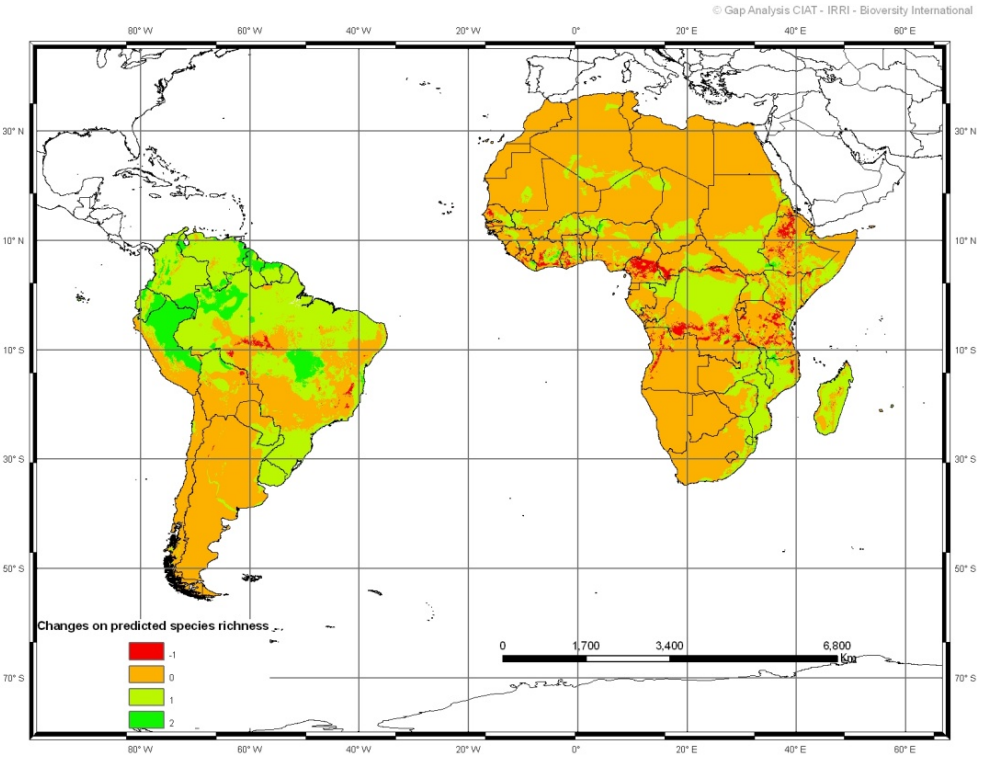


**Figure 4: Changes on predicted species richness due to climate change (http://gisweb.ciat.cgiar.org/GapAnalysis/)**

## 11. SAFETY-DUPLICATION

The safety-duplication situation varies from collection to collection. Some are safety-duplicated in one or both of the global collections (ICRISAT and USDA), however, most of the national genebanks are evaluating safety-duplication in different and distinct sites within the country. In India, most of the collections are safety-duplicated at one of its National Active Germplasm Sites (NAGS) based at Bangalore, Karnataka. Some of the Indian collections maintained at NBPGR are also part of the ICRISAT collection as safety-duplicates (1372 accessions). In the case of Southern African countries, the National collections are safety-duplicated at the Regional, South African Development Community (SADC) Plant Genetic Resources Centre (SPGRC) collection in Zambia and SPGRC is backed up at the Nordic Genebank in Sweden. Most of the ICRISAT collections are also safety-duplicated at their Regional genebank at Niami, Niger (4850 accessions) and also at Svalbard, Norway (4400). The Georgia, USA collections are also duplicated at the National Center for Genetic Resources Conservation (766 accessions) and at Svalbard Global Seed Vault (673 accessions). Part of the Kenyan collection (306 accessions) is safety-duplicated at the Nordic Gene Bank. Based on information received from survey respondents, it would seem that most of the unique national collections are not safety-duplicated. There is an urgent need to support the duplication of these collections before they are lost.

## 12. STORAGE FACILITIES AND CONSERVATION STATUS

The various storage conditions, as well as the purpose of their storage, at various national genebanks, including global collections, are presented in Table 7. From the information obtained from the survey, it has been observed that most of the collections are being maintained as long-term at -18 to -20$^{o}$C. Information for medium-term and short-term conservation has only been received from ICRISAT, Germany, Kenya, Nepal and Russian Federation.

**Table 7: Storage conditions and purpose for conserving finger millet germplasm**

| Country | Long-term conservation | | | |
|---|---|---|---|---|
| | Temp ($^{o}$ C) | Relative humidity (%) | Packing material | Purpose of collection |
| Australia | -20 | 12 | laminated foil packets | Acquisition, regeneration, documentation, health of germplasm, distribution, storage and maintenance |
| Austria | -20 | | glass jars | Acquisition, regeneration, documentation, distribution, storage and maintenance, safety-duplication |
| Bhutan | -20 | | Aluminium foil packets | Storage and maintenance |
| Burundi | -18 | | laminated aluminium foil packets | Not specified |
| China | -18 | | Aluminium box | Acquisition, regeneration, characterization, documentation, health of germplasm, distribution, storage and maintenance, safety-duplication |
| Eritrea | -18 to -20 | | Aluminium bags | Acquisition, regeneration, characterization, documentation, distribution, storage and maintenance |
| Ethiopia | | | | |
| Germany | -18 | 10 | Aluminium bags, vacuum | Regeneration, characterization, documentation, health of germplasm, distribution, storage and maintenance, safety-duplication |
| India (NBPGR) | -18 | 30-70 | Aluminium foil | Acquisition, regeneration, characterization, documentation, health of germplasm, distribution, storage and maintenance |
| Kenya | -20 | | Aluminium foil | Safe storage, characterization, evaluation, regeneration and utilization, safety-duplication |
| Malawi | -20 | 7.5 | Aluminium foil | Acquisition, regeneration, characterization, documentation, distribution, storage and maintenance, safety-duplication |

| | | | | |
|---|---|---|---|---|
| Mozambique | -20 | 5 | Aluminium foil bags | Unknown |
| Nepal | -30 | | Aluminium foil | Acquisition, regeneration, characterization, documentation, health of germplasm, distribution, storage and maintenance |
| Russian Federation | 4 -5 | 6.5 | Laminated aluminium foil bags | Regeneration, characterization, documentation, distribution, safety-duplication |
| Senegal | | | | |
| South Africa | -18 | | Aluminium foil bags | Safety-duplication |
| Sri Lanka | 1-5 | 25-35 | Aluminium foil bags and tin cans | Regeneration, characterization, documentation, distribution, storage and maintenance |
| Tanzania | -18 | | | Acquisition, regeneration, characterization, documentation, health of germplasm, distribution, storage and maintenance |
| United Kingdom, Kew | -20 | | Glass material | Acquisition, regeneration, documentation, health of germplasm, distribution, storage and maintenance, safety-duplication |
| USA, Griffin, Georgia, | -18 to -14 | 26 | Glysine lined bags and heat sealed foil bags | Acquisition, regeneration, characterization, documentation, health of germplasm, distribution, storage and maintenance, safety-duplication |
| Vietnam | 5 | 45-50 | Aluminium packages | Acquisition, regeneration, characterization, documentation, health of germplasm, distribution, storage and maintenance |
| Zambia | -20 | 15 | Aluminium foil bags | Acquisition, regeneration, characterization, documentation, storage and maintenance |
| GLOBAL (ICRISAT) | -20 | | Laminated aluminium foils | Regeneration, characterization, documentation, health of germplasm, distribution, storage and maintenance, safety-duplication, strategies for enhancing use of conserved germplasm and collaborative evaluation with NARS |

## 13. REGENERATION NEEDS

The regeneration needs for landraces, improved varieties, breeding materials and wild species by individual countries are presented in Table 8. For landraces, 9-100% of the total accessions being maintained by each genebank were described as needing to be regenerated, whereas the proportion of wild species accessions needing to be regenerated ranged from 10-30% and has only been indicated by ICRISAT, Kenya and Tanzania. While information is not available from most of the national genebanks, it is expected that many collections have high regeneration needs which in some cases may be urgent.

As per the regeneration guidelines developed by Bioversity International with support from the Trust, regeneration is necessary when: seed stocks are <50g; germination falls below 75%; >25% of seeds are infected by one or more fungi, such as *Alternaria, Aspergillus, Cladosporium, Curvularia, Fusarium, Macrophomina, Penicillium, Phoma* and *Rhizopus* spp. (Rao and Bramel, 2000). In order to maintain genetic integrity, it is recommended to use seed from the original source, as far as possible. A minimum of 3g seeds is required to obtain a plant population of 120 plants for regeneration of a germplasm accession. Because of small seed size, care is required while preparing seed samples. The seed should be treated with a fungicide to control seed-borne fungi. For each accession, prepare one seed packet for planting each row and label the packets with identification number and row number and arrange them according to field layout. Finger millet is a self-pollinated crop and seed regeneration does not require any pollination control. Leave a distance of 3m between accessions.

**Table 8: Regeneration needs (expressed as a percentage) of finger millet germplasm collections**

| Country | Total number of accessions | Germplasm type | | | |
|---|---|---|---|---|---|
| | | Wild sp. (%) | Landraces (%) | Others (obsolete, advanced/ improved and breeding materials) (%) | Remarks |
| Australia | 13 | | | | No samples need regeneration at the present state of conservation |
| Austria | 10 | | 100 | | |
| Bhutan | 84 | | | | No samples need regeneration at the present state |
| Burundi | 113 | | 100 | | |
| China | 300 | | | | No samples need regeneration at the present state of conservation |
| Eritrea | 120 | | | | No samples need regeneration at the present state of conservation |
| Germany | 22 | | | | No samples need regeneration at the present state of conservation |
| India | 10507 | | | | No samples need regeneration at the present state of conservation |
| Kenya | 2920 | 30 | 80 | 90 | |
| Malawi | 145 | | 20 | | |
| Mozambique | 12 | | 100 | | |
| Nepal | 877 | | 50 | | |
| Russian Federation | 110 | | 9 | 140 | |
| South Africa | 17 | | | | No samples need regeneration at the present state of conservation |
| Sri Lanka | 393 | | 25 | 25 | |
| Tanzania | 293 | 10 | 30 | | |
| United Kingdom, Kew | 1 | | | | No samples need regeneration at the present state of conservation |
| USA, Georgia, Griffin | 756 | | | 4.1 | |
| Vietnam | 52 | | 30 | | |
| Zambia | 497 | | 40 | | |
| GLOBAL (ICRISAT) | 5957 | 20 | 20 | 35 | |

## 14. FINGER MILLET COLLECTIONS: DISTRIBUTION STATUS

The availability of finger millet accessions from different countries is presented in Table 9. Out of 40 countries responding to the survey only 15 countries have indicated their willingness to share their accessions and the percentage of accessions made available varied from country to country.

**Table 9: Distribution status of finger millet germplasm**

| Country | Total number of accessions | Percentage of accessions available for distribution (%) | | |
|---|---|---|---|---|
| | | Wild sp. | Landraces | Others (obsolete, advanced/improved and breeding varieties) |
| Austria | 10 | | 100 | 100 |
| Burundi | 113 | | 100 | |
| China | 300 | | 100 | |
| Eritrea | 120 | | 50 | |
| Germany | 22 | 50 | | 100 |
| India | 10507 | 100 | 100 | 100 |
| Kenya | 2920 | 50 | 70 | 90 |
| Malawi | 145 | | 100 | |
| Nepal | 877 | | 10 | |
| Russian Federation | 110 | | 50 | 100 |
| Sri Lanka | 393 | 5 | 5 | 5 |
| Tanzania | 293 | 40 | 40 | |
| USA, Georgia, Griffin | 756 | 100 | 100 | 95.9 |
| Vietnam | 52 | | 80 | |
| Zambia | 497 | | 80 | |
| GLOBAL (ICRISAT) | 5957 | 90 | 90 | 90 |

## 15. MAJOR GAPS AND LIMITATIONS IN THE MANAGEMENT AND USE OF FINGER MILLET GERMPLASM

In order to accurately assess the gaps in the genetic diversity held in collections world-wide it would first be necessary to complete the georeferencing of all existing accessions and map this against data on the distribution of the area of finger millet cultivation and the distribution of its wild species. However, few countries (Bhutan, Burundi, Eritrea, Kenya, South Africa, Sri Lanka, Tanzania, Vietnam and Zambia) indicated gaps in their collections and the need for support for collecting germplasm from identified areas. ICRISAT also indicated gaps in their collections which could be filled with sufficient resources and funding support. Major limitations for sustainable *ex situ* conservation have also been identified by many National Programmes such as low priority on finger millet, declining funding for its conservation, lack of trained and experienced staff, lack of facilities for multiplication

and regeneration, limited availability of modern technology and tools for germplasm characterization and evaluation.

The various factors limiting use of finger millet germplasm indicated by the partners are: shortage of staff trained on finger millet breeding, lack of availability of characterization and evaluation data, low amount of seed available for distribution, the tendency of breeders to use their own material and little interaction with genebank staff. The details of individual country information received for gaps, limitations and factors limiting use are presented in Table 10.

**Table 10: Major gaps in the collections, limitations in the management and factors limiting the use of global finger miller collections**

| Country | Gaps in collection | Major limitation for *ex situ* conservation | Factors limiting use |
|---|---|---|---|
| Australia | YES | Declining funding; low priority on finger millet as it is not a highly utilized germplasm set | The driver for use is an applied breeding programme, or established industry for new cultivar development. There is a very small finger millet industry in Australia, but no active breeding programme that is utilizing material from our collection. This limits the use of our collection to community gardeners and generally to academic researchers, who do not use large number of accessions. |
| Austria | NO | Not specified | Not known yet |
| Bhutan | YES | Lack of staff; only at initial stage of collecting germplasm; lack of facilities for pest and disease screening | Staff shortages; at initial stage of collecting germplasm; lack of facilities for pest and disease screening |
| Burundi | YES | Not specified | Not known yet |
| China | NO | Not specified | Scarce number of seeds |
| Eritrea | YES | Lack of training and experience; lack of facilities for safe accessions multiplication and regeneration; lack of relevant genebank equipment and modern technologies for germplasm characterization | No finger millet breeders |
| Germany | NO | No limitations | No field cultivation possible under German environmental conditions |
| Hungary | NO | | |
| India | NO | Characterization and evaluation; availability of complete information in electronic format not complete; trait-specific accessions to be identified; lack of feedback | Characterization and evaluation; availability of complete information in electronic format not complete; trait-specific accessions to be identified |
| Indonesia | NO | | |
| Kenya | YES | Germination protocols for some wild relatives; staff and funding levels | Majority of accessions are yet to be characterized and/or evaluated; limited information on the available germplasm; limited attention given to pearl millet research |
| Malawi | NO | Lack financial support to maintain and promote | Limited knowledge on importance of finger millet as this is an |

| | | | |
|---|---|---|---|
| | | underutilized finger millet collection; limited knowledge available to users of finger millet collection; limited capacity in terms of human resources and equipment; status of finger millet as underutilized crop in Malawi; not a priority crop | underutilized cereal in Malawi |
| Mozambique | YES | Low amount of seeds stored at the genebank; most finger millet germplasm is affected by birds in the field | Low amount of seeds stored at the NPGRC;<br>very few collections targeting finger millet have been covered by the NPGRC so far |
| Nepal | YES | Inadequately trained manpower, resources and facilities | Limited work on crop improvement; insufficient information |
| Russian Federation | | Insufficient quantity of seeds for a few accessions | Insufficient quantity seeds of some accessions |
| Sri Lanka | YES | Lack of funds for carrying regeneration | Not known yet |
| Tanzania | YES | Lack of funds for carrying out regeneration; frequent power cuts | Not many people are aware of our collections;<br>breeders have a tendency to keep their own materials as source of genes for breeding |
| Ukraine | NO | | |
| United Kingdom, Kew | NO | Not specified | Not known yet |
| USA, Georgia, Griffin | NO | Land for regeneration; labour for regeneration; disease control during regeneration | Not known yet |
| Vietnam | YES | Lack of facilities, methodology, equipment, human resources and location for seed multiplication and breeding | Lack of breeding programmes for selecting new potential finger millet varieties in our collections |
| Zambia | YES | Inadequate and irregular financial resources for regeneration and characterization of the collection; inadequate storage space of the collection in the genebank; limited facilities for germination testing and other seed management; inability to retain staff | Lack of evaluation data; limitation on media for information dissemination about the collection |
| GLOBAL (ICRISAT) | YES | Inadequate funds, Lack of experienced personnel; insufficient manpower | Knowledge on traits of economic importance and adaptation. This has been overcome by identifying core and mini-core collection at ICRISAT. |

## 16. DOCUMENTATION STATUS OF FINGER MILLET COLLECTIONS

Table 11 summarizes information on the availability of passport, characterization, and evaluation data in electronic format on collections. Passport information is computerized in most of the collections. However availability of electronic characterization/evaluation data is lower. Many countries have indicated that these data are freely available on request. The countries maintain information in different platforms such as MS Access, MS excel, SQL server 2005, Oracle9i, visual basic and front end designing and GRIN. The collections of SADC member countries are being documented using SADC documentation and information systems and are also available through the SPGRC website.

At ICRISAT, computerization of data started in 1980 using the ICRISAT Data Management and Retrieval System (IDMRS) software developed at ICRISAT. ThenSystem 1032 was used and is now maintained using MS Access for faster and more efficient data management. Databases include: passport, characterization, inventory and distribution. Passport and characterization databases can be accessed through http://SINGER.grinfo.net. Germplasm catalogues were prepared using multi-locational evaluation data.

**Table 11: Status of electronic data on finger millet germplasm**

| Country | Passport data | Characterization data | Evaluation data |
|---|---|---|---|
| Australia | YES | YES | YES |
| Bhutan | YES | NO | NO |
| Burundi | YES | NO | NO |
| China | YES | YES | YES |
| Eritrea | YES | YES | NO |
| Germany | YES | YES | NO |
| India | YES | Partially (20%) | Partially (10%) |
| Kenya | YES | Partly | NO |
| Malawi | YES | YES | NO |
| Mozambique | YES | NO | NO |
| Nepal | YES | NO | NO |
| Russian Federation | YES | YES | YES |
| South Africa | YES | YES | YES |
| Sri Lanka | YES | YES | NO |
| Tanzania | YES | YES | YES |
| United Kingdom, Kew | YES | NO | NO |
| USA, Georgia, Griffin | YES | YES | YES |
| Vietnam | YES | YES | YES |
| Zambia | YES | YES | NO |
| GLOBAL (ICRISAT) | YES | Partially (20%) | Partially (20%) |

The following databases can also be searched to gather information for finger millet and the respective contact details:

1. GENESYS (http://genesys-pgr.org/)
2. SINGER (http://singer.cgiar.org/)
3. EURISCO (http://eurisco.ecpgr.org/)
4. FAO-WIEWS (http://apps3.fao.org/wiews/wiews.jsp?i_l=EN)

## 17. A BRIEF OVERVIEW OF FINGER MILLET GERMPLASM CONSERVATION BY COUNTRY

### Australia

Australia maintains 13 accessions as long-term collections. The collection could be used as a basis for breeding, but significant introduction of more representative germplasm would be required for any applied breeding programme, since the collection is a very small subset of the global collection. The normal regeneration interval to maintain the viability of the finger millet collection is 9-10 years to increase seed stocks or when the seed viability declines below 80%. The health testing is however satisfied when all imported seeds clear quarantine with disease-free status. The weed status of the *Eleusine* species accessions prevents distribution. The software used for maintaining the collection is the SQL Server with Visual Basic Front End. The users are updated through the web based AusPGRIS germplasm information system, mails, web portals.

### Austria

The Austrian Agency for Health and Food Safety (AGES) maintains ten accessions of finger millet. Seeds are maintained under long-term storage conditions. Normal regeneration interval to maintain the viability of the finger millet collection is 20 years. The software used for maintaining the collection is MS Access. Germplasm is available for international distribution through the SMTA. Potential users are informed about the collections through the EURISCO database which is regularly updated.

### Bhutan

Bhutan maintains 84 accessions which were collected from sub-tropical to warm temperate zones. The collection needs characterization and diversity analysis. Seeds are maintained under different storage facilities (long-term and short-term). The collections are being documented using MS Access. The users are being informed about the collection through the internet and published information. The finger millet collection has not been regenerated since the first ever collection was made in 2005. However, it ensures viability testing from 2011 for those samples collected at the initial stage back in 2005-2007. Acute shortage of staff and lack of trained manpower is the main constraint.

**Burundi**

Burundi maintains 113 accessions. Seeds are maintained under long-term storage with the main aim of saving indigenous cultivars from extinction due to abandonment by farmers, mainly due to the fact that finger millet is labour intensive and low yielding compared to cereals. Germination tests performed are to international standards. The software used for maintaining the collection is the SQL Server with Visual Basic Front End. Users are updated through the internet, field days and publications. Finger millet is of high nutritional value but becoming a neglected crop due to overpopulation and high demand in labour and its vulnerability to climate change. The loss in genetic material is high and there is a potential weakness in germplasm characterization as there are no breeding strategies being developed to improve the crop.

**China**

China is one of the major East Asian countries maintaining 300 accessions of the finger millet collection. No gaps have been identified. Seeds are stored under long-term and medium-term storage conditions. As the number of seeds is limited, the collection is used only as a forage crop. The crop is not of particular importance to China, so relatively little work is being done for its improvement. The users are informed about the collection through the internet.

**Eritrea**

The National Agricultural Research Institute maintains a total of 120 accessions of finger millet for long-term and short-term conservation. No seeds have been regenerated so far for long-term conservation. ISTA methods are used for germination testing and viability testing is revised every ten years. Potential users are informed about the collections through database, meetings and workshops.

**Ethiopia**

Several requests were made to national PGR programmes; however, no response was received. The Head of Ethiopia's PGR programme was also invited to the global consultation meeting which was organized on 22-23 December 2011 in New Delhi, India but no representative from Ethiopia participated in the meeting. Hence the information provided in this report is based on a literature survey and the information obtained from available databases.

**Germany**

The Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) maintains 22 accessions of finger millet under long-term conservation. The safety-duplicates are however maintained by the Svalbard Global Seed Vault (SGSV) for long-term storage under special regulation. Normal regeneration interval to maintain the viability of the finger millet collection is 20-30 years. Germination tests are carried out regularly. The software used for maintaining the collection is the Oracle-based database. Potential users are informed about the collections through the internet.

**India**

The National Bureau of Plant Genetic Resources (NBPGR) maintains a total of 10507 accessions, with good coverage and no gaps reported. Seeds are maintained under long- and medium-term storage. The importance of finger millet for use and breeding includes a few breeding lines which have been identified for traits such as early maturity, high grain yield and straight panicle. Germination tests are carried out on a regular basis. Data are being documented using MS Access and Excel. The utilization of germplasm is enhanced through the publication of a crop germplasm catalogue and also through the development of core and mini-core sets. The users are informed about the collection through field demonstrations and participation in AICRP workshops.

**Kenya**

Kenya Agricultural Research Institute, the National Genebank of Kenya, is a governmental organization that maintains a total of 1902 accessions. The indigenous collection includes accessions from Eastern Kenya (676), Western Kenya (433), Rift valley (358), Nyanza (106), Central Kenya (9), Nairobi (5), Coast (3) province and the exotic collection includes accessions from Zimbabwe (270), Malawi (99), Zambia (74), Ethiopia (25), Tanzania (21), Uganda (7), India (2), Burundi (1) and Mozambique (1). The germplasm is monitored for viability and possible recommendation for regeneration every ten years. This activity is behind schedule. The permafrost at Svalbard maintains safety-duplicates of 306 accessions under long-term storage conditions in black-box. The electronic information system software used for managing the finger millet collection is MS Access.

**Malawi**

There are 145 accessions of finger millet maintained at the Plant Genetic Resource Centre of Malawi, which ensures the long-term availability of a wide diversity of finger millet for breeding and other research programmes. No gaps have been identified so far. Seeds are maintained under long-term storage conditions at the SADC Genebank (air-tight bottles) and are further duplicated to the Nordic Gene Bank (black-box). However, the most interesting aspect of the collection is the yield potential, and that it is early maturing, rich in nutrients and many food products could be developed from the crop. The importance of finger millet for use and breeding includes the availability of a wide diversity of germplasm. The normal regeneration interval to maintain the viability of the finger millet collection is ten years. The health testing is done by monitoring seed-borne diseases during the growing period, harvesting and germination. The software used for maintaining the collection is the SPGRC Documentation and Information System. All of the germplasm is available for distribution nationally, regionally and internationally. The utilization of germplasm is enhanced by the SPGRC regional network, which ensures the long-term conservation of crop germplasm in SADC region. The collections are publicized through brochures, field days, agricultural shows and workshops.

**Mozambique**

The National Plant Genetic Resources Center (NPGRC) maintains 12 accessions of finger millet. Collecting missions are also conducted in the country where indigenous knowledge (IK) has been recorded. So far, only two collection missions have been

conducted specifically targeting finger millet in Mozambique. Therefore, the number of accessions held by the NPGRC currently does not represent the genetic diversity distributed within the country. Seeds are maintained under long-term and short-term storage conditions. Some of the local varieties within the collection have specific traits such as drought tolerance and good taste. The normal regeneration interval to maintain the viability of the collection is five years. The germination, viability and health testing is carried out by the National Seed Services Department. The software used for maintaining the collection is the SDIS Software (SADC Documentation and Information System). The utilization of germplasm is enhanced by SPGRC regional network which ensures the conservation and utilization of plant germplasm to enhance regional food security and economic security. The potential users are informed about the collections through the website of Instituto de Investigação Agrária de Moçambique (IIAM) website, planning meetings and international conferences.

**Nepal**

The Nepal Agricultural Research Council (NARC) maintains 877 accessions of finger millet. Seeds are maintained under long-, medium- and short-term storage. The finger millet collection is important for their breeding programmes due to fact that it is a staple food for mountain and diabetic people, most suitable for marginal land and is a rich source of iron for women and children. Seasonal tests are being performed to check the germination and viability of the crop. Passport data have been computerized using Ms Excel. Users are informed about the collection through publications, field days, workshops and online databases.

**Russian Federation**

The N.I. Vavilov Research Institute of Plant Industry (VIR) in St. Petersburg maintains a vast long-term, working collection of 110 accessions of finger millet. Seeds are stored under long-, medium- and short-term storage conditions. Importance of finger millet for use and breeding includes early maturity, high grain yield, high green matter yield, high crude protein content, drought resistance, tolerance to high salinity; it is used as a fodder crop. The normal regeneration interval to maintain the viability of the finger millet collection is 10-15 years. Germination and viability tests are carried out by soaking the seeds in water at $20^0$C for a day, after which the seeds are put in wet paper for 4-10 days. The software used for maintaining the collection is Paradox 9. Thirty percent of germplasm is available for national distribution. Potential users are informed about the collection through publications in journals.

**Sri Lanka**

The Plant Genetic Resources Center (PGRC) maintains 393 accessions within finger millet collections. Major gaps have been identified, especially collections from Northern and Eastern provinces of the country. Seeds are stored under long- and short-term conservation and are being used as a resource within the crop improvement programme. Normal regeneration interval to maintain the viability of the finger millet depends on viability and quantity of accessions. Germination tests are performed at a five-year interval and viability is tested every ten years. The software used for maintaining the collection is Oracle 9i and the Material Transfer Agreement (MTA) is required for distribution of finger millet accessions. 100% of accessions within the

finger millet collections are available for distribution. Users are informed about the collection through annual reports.

**Tanzania**

Finger millet is one of the traditional main food crops endemic to dry areas of Tanzania, which maintains 293 accessions. However, there are a few gaps in the collections which need to be filled by undertaking multi-crop germplasm collection and exploration missions. Seeds are maintained under long-term base collections for future use, the working collection to be used by breeders and other researchers to produce improved varieties. The safety-duplicates are maintained at the SADC Plant Genetic Resource Centre for long-term conservation in deep freezers. Normal regeneration interval to maintain the viability of the finger millet collection is 5-10 years. Germination tests are carried out prior to collection from farmers and before distributing to users. Viability testing is done every five years of storage and where viability is less than 70%, regeneration is carried out. The software used for maintaining the collection is the SDIS Software. The potential users are informed about the collections through workshops and participation in on-farm conservation. 40% of germplasm is made available for national and 20% for regional distribution.

**USA**

The United States Department of Agriculture, National Plant Germplasm System maintains 765 accessions of finger millet germplasm for long-term conservation and provides the material freely for research purposes. So far, the major gap identified is consolidating collaboration with other germplasm centres that would be willing to donate material to the US collection, including the core and mini core sets developed elsewhere. Seeds are maintained under long-term storage at the Svalbard Global Seed Vault and the National Centre for Genetic Conservation, fully integrated into the host collection. The most unique feature of the collection is that a substantial number of its accessions hold a great wealth of diversity, as evidenced by morphological characters. Normal regeneration interval to maintain the viability of the finger millet collection varies depending on the viability testing results, number of seeds in storage and seed age. Regenerated and newly acquired accessions are tested prior to storage. Ninety-two% of the accessions have been tested to date. One hundred seventy accessions have been distributed nationally and 20 accessions internationally. Potential users are informed about the finger millet accessions through the internet, emails, letters and telephone correspondence.

**Vietnam**

The Socialist Republic of Vietnam maintains 52 accessions of finger millet in the national genebank, primarily to supply materials to users in field studies, seed breeding programmes and to introduce potential varieties for production based on characterization and evaluation of agrobiomorphological characteristics. Seeds are stored for long-term conservation. Germination tests are carried out annually by putting the seeds under wet sand for a period of 1-2 days and then counting the number of germinated seeds. Information on the finger millet collection is not yet computerized but is planned to be within the next two years. Germplasm is made available free of charge for research purposes but requires feedback. The users are informed about the collection through the centre website and scientific publications.

## Zambia

The Zambia Agricultural Research Institute is responsible for holding a vast collection of 497 accessions. There are a few gaps identified, however targeted collection for controlled agro-ecological regions and to spearhead systematic collection of wild relatives are the steps that have been taken to fill these gaps. Seeds are maintained under long-term storage conditions. The safety-duplicates are maintained at the SADC Plant Genetic Resource Centre for long-term storage and are fully integrated into the host collection. The most unique feature of the finger millet collection is the tolerance of soil acidity, time of maturity, panicle and grain size, as well as yield related traits, micronutrient density and breeding for wide adaptation including soil acidity conditions. Normal regeneration interval to maintain the viability of the finger millet collection is less than ten years. A germination threshold level of 85% is used as a determining factor for undertaking regeneration of germplasm accessions. The software used for maintaining the collection is the SDIS Software. Potential users are informed about the collections through field and open days, and also through annual and technical reports.

## Global collection

ICRISAT aims to serve as the world repository for germplasm holding and presently holds 5957 accessions, which also include wild relatives. However, geographical, eco-regional and diversity gaps need to be identified for further exploration and collecting. Seeds are maintained under long-, medium- and short-term storage. ICRISAT collections are also stored at the Svalbard Global Seed Vault, Norway (4400 accessions) and at the ICRISAT Regional Genebank (4850 accessions), Niamey, Niger. The most interesting aspect of the finger millet collection, making it unique, is the highly diverse germplasm representing major races and sub-races, which includes sources of resistance to important biotic and abiotic stresses, and adaptation and nutritional quality traits, which are very useful in crop improvement programmes. ICRISAT is also responsible for enhancing the use of these collections in plant breeding, which is being done through the development of core (622 accessions) and mini-core sets (80 accessions) and identification of trait-specific germplasm. Normal regeneration interval to maintain the viability of the finger millet collection is 8-10 years for medium-term storage accessions and 15-20 years for long-term storage accessions. Top of paper method using 50 seeds in two replications is being used for germination and viability testing. The health testing is done by visual examination and blotter test, and agar plate method to identify seed-borne pathogens. The software used for maintaining the collection is the SQL Server 2005. The number of accessions distributed annually (average of the last three years) is 3286 accessions distributed nationally and 1129 accessions internationally. The Standard Material Transfer Agreement (SMTA) under the International Treaty is required for distribution of finger millet accessions. The utilization of germplasm is enhanced by SINGER, the Cereal Legumes Asian Network (CLAN) and the Asia Pacific Association of Agricultural Research Institutions (APAARI). The users are informed about the collection through publications, field days, workshops and online databases.

## 18. CONCLUSION AND RECOMMENDATIONS

From the survey carried out and the information gathered from literature and databases it has been concluded that there are approximately 24666 accessions across various genebanks at the global level. Three genebanks, namely (1) ICRISAT, (2) NBPGR, New Delhi and (3) NAGS – AICSMIP, Bangalore, India conserve the largest collections. Together, these three genebanks account for 16482 accessions which make up 67% of the global collection. Among South Asian collections, Indian and Nepalese collections may be fairly adequate, except for Bhutan and Sri Lanka. Collections from East and South Africa are less than adequate. In Africa, the primary centre of origin, there is a definite possibility of new diversity emerging by frequent introgression of wild and weedy forms (*E. africana*) with cultivated forms. This is occurring unhindered in nature because of the proximity of *E. africana* and *E. coracana* occupying the same habitat. This gene flow provides ample scope for the emergence of new diversity in the primary centre and should be collected. Collections from China and Japan are fewer in number and need to be integrated through further collecting. Collections of weedy forms, *E. africana* and wild species including the most widespread *E. indica* are fewer in number. Therefore, systematic efforts are needed to further increase these collections.

The main reason for lack of finger millet utilization is due to the poor quality of the evaluation data base both for quantitative as well as qualitative traits. Only a fraction of available germplasm is being used in crop improvement programmes for finger millet worldwide. Therefore, the economic value and usefulness of the large amounts of conserved germplasm in almost all genebanks is still to be assessed. This activity needs to be strengthened as a priority and should receive attention in all genebanks/countries. The need for a common platform for free exchange of ideas and use on germplasm management related to finger millet has been keenly felt by curators. Finger millet grain is highly nutritious and thus calls for intensive evaluation of germplasm to assess its nutritional qualities. Genebanks with a modest number of collections should be encouraged to form core sub-sets and this would lead to more efficient management and utilization of the collections. Regular monitoring of collections, especially for seed viability and vigour is of utmost importance to prevent erosion of accessions at the genebank level. It is desirable that all accessions stored for more than 15 years under medium-term conditions (even in well managed genebanks) be considered for regeneration and replacement of seed stocks.

In order to discuss the draft strategy prepared, based on the information received through surveys and also from various published literature and databases, a consultation workshop was organised on 23 December 2011 to agree upon final recommendations for sustainable management and use of finger millet germplasm. A total of 20 participants representing India, Mali, Senegal, Uganda and Kenya took part in this consultation workshop. For more details see Appendix 3. The workshop agenda is presented as Appendix 4.

During the morning session of the workshop Dr. PN Mathur, South Asia Coordinator, Bioversity International gave a detailed presentation on the background and details of work for the *ex situ* conservation of finger millets and their wild relatives. The participants then had a detailed discussion on the general topics of conservation of finger millets and compared the country-specific strategies that are being followed.

The afternoon session of the workshop was reserved for group discussions. The participants were divided into two groups, comprising an even mix of representatives from both Asia in Africa in each group. After an intensive discussion pertaining to the detailed list of topics, each group gave a short presentation of their findings and proposed strategies. The group participants were as follows:

Group 1:

1. Dr. MVC Gowda, India: Group Chairperson
2. Dr. HD Upadhyaya, India
3. Dr. C Tara Satyavathi, India
4. Dr. Desterio Ondieki Nyamongo, Kenya
5. Mr. Ousmane Sy, Senegal
6. Dr. Nidhi Verma, India

Group 2:

1. Dr. A Seetharam, India: Group Chairperson
2. Dr. RK Tyagi, India
3. Dr. M Dutta, India
4. Dr. Amadou Sidibe, Mali
5. Dr. Chrispus Oduori, Kenya
6. Nelson Wanyera, Uganda
7. Dr. Sushil Pandey, India

Based on the presentations and discussion during the workshop the groups agreed upon the following recommendations:

**1. Review of data on various collections**

The representatives went over the existing records and, based on their knowledge of the current status in their respective countries, they updated the records for their respective countries. They also recommend the following:

- More collections with emphasis on wild relatives should be made from eastern and southern African countries (e.g. Kenya, Uganda, Ethiopia, Tanzania, Zimbabwe, Zambia);
- NAGS holdings from India should also be included along with the biological status (landraces/varieties/exotic collections, etc.);
- There is need for greater exchange of germplasm material from Asia to Africa and vice-versa;
- Biological status of the material should be defined wherever sizable collections exist and their storage conditions should also be mentioned;
- More effort is needed to update the collection status as many of the country data do not accurately reflect the real situation (e.g. Ethiopia).

**2. Consider the proposed criteria for a reference collection**

Based on the size of collections, diversity and uniqueness, genebanks can be designated as reference centres. However, this status should be awarded subject to the condition that they have appropriate and standard storage/conservation facilities.

**3. Identify other significant collections**

The following organizations and countries were identified as having significant collections:

- Zambia
- Nepal
- Sri Lanka
- Tanzania
- China

**4. Potential partners for conservation services**

The following organizations and key persons within those organizations were identified as potential partners for conservation services:

- ICRISAT, India
- Mr. Ousmane Sy, Senegal
- NBPGR, India
- ILRI, India
- CIRA
- IARI, India
- Dr. Wanyera, NaSARI, Uganda
- Kenya Agriculture Research Institute, Kenya
- NARO, Uganda
- Maseno University, Kenya
- ASARECA,
- SADC and
- NARS (like AICRP, India)

**5. Gaps in collections**

- Dry northern rift valley in Kenya, Western Uganda and other important regions of eastern and southern Africa;
- Concerted efforts for acquisition of germplasm from China, Japan and other Central Asian countries;
- Among wild relatives, more collections needed for *E. indica*. However, introgression between cultivated and wild (*E. africana*) is available at the primary centre of origin;
- Other areas should be identified based on gap analysis (traits, diversity and uniqueness).

**6. Current status of Information Systems**

- Adoption of the GRIN-Global and GENESYS databases at the global level will enhance database management and information access. However, these databases need to be updated with georeference information;
- Capacity building for database development in African countries is required;
- Germplasm Information System needs to be strengthened in India and with NARS partners;
- Sharing of information on germplasm should be in compliance with a country's national policy;
- Awareness among the national partners on the importance of Information Management System and their sharing mechanism is necessary;

- Finger millet mini-core has been evaluated extensively in India (ICRISAT, Nandyal, Vijaynagaram, Mandya and Dholi) and in Kenya, Tanzania and Uganda for agronomic traits and for drought, salinity and blast resistance under controlled conditions and in the field;
- Once available this information will be useful to the breeders and farmers.

**7. Safety-duplicates**

- All the unique collections should be kept as safety-duplicates and the countries which have the capability to create safety duplicate facilities should be encouraged to do so. Countries without this capability, but still possessing significant genebanks, should develop a system for conserving the unique accessions as safety-duplicates where possible like the regional genebanks, the CGIAR Genebanks and the Svalbard Svalbard Global Seed Vault as per their feasibility;
- Designated ICRISAT accessions should be duplicated at the Svalbard Global Seed Vault;
- Senegal's germplasm has already been duplicated at ICRISAT;
- To improve the situation the exchange of passport data must be encouraged and agreed guidelines adhered to.

**8. Policy and Technical impediments to enhanced use**

- Countries that are not keen to exchange germplasm;
- The cost involved in the regeneration and distribution of the material;
- Lack of infrastructure e.g. cold stores especially in the national systems;
- Uncharacterized material in genebanks;
- Harmonization of national policy in compliance with ITPGRFA for enhanced sharing. Countries should take the initiative to designate and multiply their germplasm in sufficient quantity to share it, on a priority basis, as per the ITPGRFA provisions;
- Countries lacking well evolved quarantine and phytosanitary facilities should be supported in setting up a system through capacity building and infrastructure development;

**9. Cooperative Programmes**

The following have been identified as significant networks or international organizations that already exist:

- ASARECA - Association for Strengthening Agricultural Research in Eastern and Central Africa
- SAFGRAD - Semi-Arid Foodgrains Research and Development
- INTSORMIL - International Sorghum and Millets

To enhance the cooperative programmes, the following points have also been identified:

- Strengthening networks by encouraging regional collaborative projects and mutual respect;
- South-South collaboration between India and Africa using climate analogues can be a significant programme for future development of conservation;
- Civil society organizations are also quite effective for on-farm conservation and participatory research. They can be effectively utilized in PGR programmes;

- Cooperative programmes are also needed for the biochemical evaluation of different quality parameters.

**10. Effectiveness of links to users (breeders/farmers)**

The weaknesses in the path of effective links are:

- Inadequate stocks and lack of evaluation of accessions at genebanks;
- Poor information flow between genebanks and users regarding trait availability and lack of user feedback;

The solutions that can be implemented to address these weaknesses are:

- Generation of reliable information on accessions, characterization and evaluation;
- Publication of information;
- Enhanced interaction between genetic resources professionals and users through field days and hosting of demonstration plots;
- Strong linkage between Genebanks and Crop Based Institutes. Genebanks should be involved in characterization and detailed/advanced evaluation should be carried out by the breeders;
- Development of core sets and elite germplasm sets (EGS) should be developed for wider scope of use by breeders;
- Pre-breeding activity should be strengthened;
- Participatory *in situ* - *ex situ*/On-farm genebank management (including characterization) through farmers' participation and creation and strengthening of community genebanks is required.

**11. Training needs (Capacity Building)**

Capacity building needs have been identified as:

- Conservation and quarantine (including seed technological aspects), bio-systematic, pre-breeding, advanced evaluation;
- Systems of Regeneration (especially in cross-pollinated crops like finger millets), Genebank management;
- Characterization, Evaluation, Documentation, Database management and Data analysis;
- Socio-economics in conservation;
- Bioversity International should play a proactive role in organizing these capacity building programmes.

**12. Key steps and strategy**

The following key steps and strategies have been proposed for effective conservation:

- Identifying unique collections and accessions;
- Assisting endangered collections and regeneration to preferred international standards
- Identifying germplasm collection subsets for extensive evaluation to identify trait-specific accessions for traits of economic importance to enhance germplasm utilization;
- Greater focus should be placed on the nutraceutical traits;
- Trait-specific evaluation for tolerance to drought, salinity, blast, *Striga*, high temperature;
- Malting, brewing and popping qualities should be noted;
- Structured PGR programmes taking all aspects into account and accordingly identifying the institutional mechanisms.

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**APPENDIX 1: Survey Questionnaire**

**Survey Questionnaire:**
**Finger Millet Conservation Strategy Survey - August 2010**

## 1. Background

The Global Crop Diversity Trust is undertaking a series of studies to support the development of international collaborative conservation strategies for different crops. As such strategies evolve, they will provide a basis for the allocation of resources from the Trust to the most important and needy collections with the specific goal of supporting the costs of conserving national and international crop diversity collections over the long time.

This questionnaire has been developed in order to seek the advice and input of representatives of the world's major finger millet collections in the development of the finger millet conservation strategy. In particular the questionnaire aims to assess the status of finger millet conservation throughout the world. As the strategy document is intended to be made available publicly, results of the survey could be included and therefore published.

As curator of a key finger millet collection, we kindly request you to complete the sections 1-17 of the questionnaire. We estimate that this procedure may take approximately 1 hour of your time. We appreciate your patience. If there are no *ex situ* finger millet collections in your institute, please can you complete sections 16-17 only. **Please return the questionnaire no later than Friday 27 August 2010 to:**

**The South Asia Coordinator**
**Dr. Prem Narain Mathur**
Bioversity International, Sub-regional Office for
South Asia
NASC Complex
Pusa Campus, New Delhi 110012, India
Tel: +91-11-25849000/01 Fax: +91-11-25849002
Email: p.mathur@cgiar.org

The Global Crop Diversity Trust is keen to have your active participation in the development of the finger millet conservation strategy and will be pleased to keep your informed on its progress. If you have any questions about this questionnaire or about the proposed strategy in general, please contact Dr. Prem Narain Mathur.

## 2. Information about your organization

| **2.1 Name and address of your organisation holding/maintaining the finger millet collection** | | | |
|---|---|---|---|
| Name: | | | |
| Address: | | | |
| City: | | Postal code: | |
| Country: | | | |
| Web site: | | | |
| **2.2 Curator in charge of the finger millet collection** | | | |
| Name: | | | |
| Address: | | | |
| City: | | Postal code: | |
| Telephone: | | Fax: | |
| Email: | | | |
| **2.3 Contact details of respondent to this questionnaire** (only if he/she is not the curator of the finger millet collection) | | | |
| Name: | | | |
| Address: | | | |
| City: | | Postal code: | |
| Telephone: | | Fax: | |
| Email: | | | |

## 3. Additional key contacts for the finger millet germplasm collection in your country

| **Name(s)** | **Title(s)/Function(s)** | **Email/Address** |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

## 4. Description of your organization

### 4.1 Please describe your own organization

1 Governmental organization
University
1 Private organization
Other (please specify): _____

**4.2 Is the institution in charge of the finger millet collection the legal owner of the collection?**

1 YES 1 NO

**4.3 Is the finger millet collection subject to the terms and conditions of the International Treaty on Plant genetic Resources for Food and Agriculture?**

1 YES 1 NO

**4.3.1 If NO, is expected to become under the International Treaty in the near future?** 1 YES 1 NO

4.3.1.1 If YES, indicate expected date: _____

**5. Overview of your finger millet collection**

**5.1 Please describe the main objectives of the finger millet collection** (long-term conservation, working collection, breeding collection etc.):

| |
|---|
| |
| |
| |
| |

**5.2 Indicate the species and the respective number of accessions from the finger millet germplasm types that are included in your collection** [Please write the number of accessions in brackets after each species name, e. g. *E. coracana* (30), etc.]**:**

| **Type of finger millet germplasm** | **Species name and number of accessions per species (in brackets)** |
|---|---|
| Wild related species of finger millet | |
| Landraces | |
| Obsolete improved varieties | |
| Advanced improved varieties | |
| Breeding/research materials | |
| Inter-specific derivatives | |
| Unknown | |
| Other | |

**5.3 Please indicate the share (in %) from each specific type of germplasm that is AVAILABLE for distribution:**

| **Type of finger millet germplasm** (where known) | **% available for germplasm** |
|---|---|
| Wild related species of finger millet | |
| Landraces | |
| Obsolete improved varieties | |
| Advanced improved varieties | |

| | |
|---|---|
| Breeding/research materials | |
| Inter-specific derivatives | |
| Unknown | |
| Other | |

**5.4 Origin of the finger millet collection: please indicate the proportion (%) of accessions on the total amount that were...** *(Note: the sum should be 100 %!)*

| **Origin** | **Proportion %** |
|---|---|
| Collected originally in your own country (national origin) | |
| Collected originally in your own country (regional origin) | |
| Introduced from a collection aboard | |
| From other origin (please define the origin): | |

**5.5 Please indicate the following about storage, moisture content/ and area under cultivation in the finger millet management:**

| **Type of finger millet germplasm** | **Duration of storage (years)** | **Moisture content at harvest (%)** | **Moisture content at storage (%)** | **Germination at storage (%)** | **Area under cultivation and average production (kg/hectares)** |
|---|---|---|---|---|---|
| Wild related species of finger millet | | | | | |
| Landraces | | | | | |
| Obsolete improved varieties | | | | | |
| Advanced improved varieties | | | | | |
| Breeding/research materials | | | | | |
| Inter-specific derivatives | | | | | |
| Unknown | | | | | |
| Other, please specify | | | | | |

**5.6 Are there major gaps in your finger millet collection?** Please indicate major gaps concerning your finger millet collection:

Species coverage of the crop: 1 YES 1 NO
Population (sample) representation per species: 1 YES 1 NO
Ecological representation of the species: 1 YES 1 NO
Other, please specify the gap concerning your finger millet collection:

5.5.1 If there are major gaps, please provide details on the plans to fill these gaps:

| |
|---|
| |
| |
| |
| |

**6. Aspects on the potential of the finger millet**

**6.1 What would you consider to be the most interesting aspects of your finger millet collection, making it unique?**

| |
|---|
| |
| |
| |
| |

**6.2 Please describe the main potential/importance of your finger millet collection for use and breeding:**

| |
|---|
| |
| |
| |
| |

**7. Conservation status (germplasm management)**

| **7.1 Please indicate the proportion (in %) of the finger millet accessions maintained under different facilities:** *(Note: if the same accessions are maintained under more than one storage condition the sum may exceed 100%)* | **Percentage %** |
|---|---|
| Short-term storage conditions | |
| Medium-term storage conditions | |
| Long-term storage conditions | |
| Other, please specify: | |

| **7.2 Please indicate the proportion (in %) of the Finger millet accessions conserved as:** *(Note: if the same accessions are stored as different types of germplasm the sum may exceed 100%)* | **Percentage %** |
|---|---|
| Seeds | |
| Field accessions | |
| *In vitro* | |
| Cryopreservation | |
| Pollen | |
| DNA | |

| | |
|---|---|
| Other, please specify: | |

**7.3 Please describe the <u>MAIN</u> storage facility available for your finger millet collection:** *(If you have **more than one** facility, please use the fields for 'additional facilities' too)*

| | **Main Facility 1** | **Additional facility 1** | **Additional facility 2** |
|---|---|---|---|
| Type of facility | | | |
| Temperature | | | |
| Relative humidity (%) | | | |
| Packing material | | | |
| Other, please specify: | | | |

| | **Additional Facility 3** | **Additional facility 4** | **Additional facility 5** |
|---|---|---|---|
| Type of facility | | | |
| Temperature | | | |
| Relative humidity (%) | | | |
| Packing material | | | |
| Other, please specify: | | | |

**7.4 Please mark for which activity you have established a genebank management system and/or have written procedures and protocols:**

1 Acquisition (*including collecting, introduction and exchange*)
Regeneration
1 Characterization
1 Storage and maintenance
Documentation
1 Health of germplasm
Distribution
1 Safety-duplication
1 Other please specify: _____

**7.5 In case you have procedures and protocols, are you able to provide the Global Crop Diversity Trust with this information (i.e. provide a copy)?**

1 YES 1 NO have procedures but not documented

**7.6 Please describe your quality control activities, in terms of frequency, protocols/methods and actions upon results:**

| **Activities** | **Description of quality control** |
|---|---|
| Germination tests: | |

| | |
|---|---|
| Viability testing: | |
| Health testing: | |
| True-to-typeness of *in vitro* plantlets: | |
| Other, please specify: | |

**7.7 Is the finger millet collection affected by diseases that can restrict the distribution of the germplasm?** 1YES 1 NO

7.7.1 If you indicated YES or slightly above, are knowledge and facilities available at your institution for eradication of these diseases?
1 YES 1 NO 1 Limited

**7.8 What is the normal regeneration interval to maintain the viability of the finger millet collection?**

| |
|---|
| |
| |
| |
| |

**7.9 Indicate the proportion (%) of each germplasm type that requires urgent regeneration.**

| **Type of finger millet germplasm** | **% available of finger millet accessions with urgent regeneration need** |
|---|---|
| Wild related species of finger millet | |
| Landraces | |
| Obsolete improved varieties | |
| Advanced improved varieties | |
| Breeding/research materials | |
| Inter-specific derivatives | |
| Unknown | |
| Other | |

**7.10 Please indicate the current situation of the finger millet collection with respect to the following conditions:** (*where: 1 = high/good, 2 = adequate/moderate, 3 = not sufficient/bad, NA = not applicable*)**.**

| **Type of finger millet germplasm** | **Current situation** | **Expected situation in 2012** |
|---|---|---|
| Funding for routine operations and maintenance | | |
| Retention of trained staff | | |
| Interest for Plant Genetic Resource | | |

| | | |
|---|---|---|
| Conservation by donors | | |
| Genetic variability in the collection as needed by users/breeders | | |
| Access to germplasm information (passport, charact., evaluation) | | |
| Active support/feedback by users | | |
| Level of use by breeders | | |
| Other factors (please specify): | | |

**8. Safety-duplications in other institutions**

*(Safety-duplication: defined as the storage of a duplicate/copy of an accession in another location for safety back-up in case of loss of the original accession.)*

**8.1 Are finger millet accessions safety-duplicated in another genebank?**

1 YES 1 NO

8.1.1 If YES, please specify in the table (and add lines as necessary):

| **Name of institute maintaining your safety-duplicates:** | **Number of accessions** | **Storage conditions (short, medium, long term)** | **Nature of the storage (e.g. black box, fully integrated in host collection, etc.)** |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

**9. Institutions storing safety-duplicates of finger millet in your genebank**

**9.1 Is there any finger millet germplasm of other collections safety-duplicated at your facilities?** 1 YES 1 NO

9.1.1 If YES, please specify in the table (and add lines as necessary):

| **Name of institute maintaining your safety-duplicates:** | **Number of accessions** | **Storage conditions (short, medium, long term)** | **Nature of the storage (e.g. black box, fully integrated in host collection, etc.)** |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

## 10. Further issues on duplication of finger millet collection

**10.1 To what extent do you consider the finger millet accessions in your collection to be unique and not duplicated extensively elsewhere (i.e. EXCLUDING safety-duplication)?**

1 Fully unique
Mostly unique
1 Partially unique
1 Fully duplicated elsewhere

**10.2 Are there any constraints to duplicating the finger millet collection elsewhere outside your country?** 1 YES 1 NO

10.2.1 If YES, please specify:_____

## 11. Information management

**11.1 Do you use an electronic information system for managing the finger millet collection (data related to storage, germination, distribution, etc.)?**

1 YES 1 Partly 1 NO

11.1.1 If YES, what software is used? _____

**11.2 Please indicate the proportion (%) of the following types of data is: (1) documented and (2) the proportion that is available electronically:**

| **Type of finger millet germplasm** | **Passport data** | | **Characterization data** | | **Evaluation data** | |
|---|---|---|---|---|---|---|
| | **Doc.** | **Electr.** | **Doc.** | **Electr.** | **Doc.** | **Electr.** |
| Wild related species | % | % | % | % | % | % |
| Landraces | % | % | % | % | % | % |
| Obsolete improved varieties | % | % | % | % | % | % |
| Advanced improved varieties | % | % | % | % | % | % |
| Breeding/research materials | % | % | % | % | % | % |
| Inter-specific derivatives | % | % | % | % | % | % |
| Unknown | % | % | % | % | % | % |
| Other, specify: | % | % | % | % | % | % |

**11.3 In case the information on the finger millet collection is not computerised, are there plans to do so in the future?**

1 No plans
1 Computerisation planned within 3 years
1 Other

**11.4 Is information of the finger millet collection accessible through the Internet?**
1 YES 1 Partly 1 NO
If YES, please indicate the address of the website:
http://_____

**11.4.1 If there is NO data available in the internet, is an electronic catalogue distributed on CD or by Email?** 1 YES 1 NO

11.4.1.1 If YES, would you be able to provide the Trust with a copy? 1 YES 1 NO

**If YES, please send a copy to Dr Prem Mathur (**p.mathur@cgiar.org**) when returning the completed questionnaire.**

**11.4.2 If there is NO data available electronically do you produce a printed catalogue?** 1 YES 1 NO

**If YES, please send a copy to Dr Prem Mathur (**p.mathur@cgiar.org**) when returning the completed questionnaire.**

**11.5 Are data of the finger millet collection included in other databases?**
National 1 YES 1 partly 1 NO

Regional 1 YES 1 partly 1 NO

International 1 YES 1 partly 1 NO

**11.5.1 If YES or partly, indicate the database** (e.g. GRIN, SINGER, EURISCO etc.):

_____

## 12. Distribution and use of material

**12.1 What proportion (%) of the total finger millet collection is AVAILABLE for the following distributions?**

Nationally: _____% Regionally: _____% Internationally: _____%

**12.2 Please fill in the number of finger millet accessions DISTRIBUTED annually, and indicate the expected change over the next 3-5 years,** where: + = increasing, 0 = no change, - = decrease

| Name(s) | Number of accessions distributed annually (average of last 3 years) | Expected change for the next 3-5 years |
|---|---|---|
| Nationally | | |
| Regionally | | |
| Internationally | | |

**12.3 Do you put specific conditions or requirements for distribution of finger millet accessions?** 1 YES 1 NO

12.3.1 If YES, please specify:

_____

**12.4 What is the proportion of finger millet germplasm sufficiently available in terms of QUANTITY for distribution?**

| Type of materials | % of accessions sufficiently available |
|---|---|
| Seeds | |
| *In vitro*/Cryopreserved material | |
| Other, please specify | |

**12.5 Is the distribution of finger millet germplasm limited because of its HEALTH status?**

- Seeds 1 YES 1 Partly 1 NO
- *In vitro* material 1 YES 1 Partly 1 NO
- Cryopreserved material 1 YES 1 Partly 1 NO
- Other, please specify 1 YES 1 Partly 1 NO

**12.6 Do you have adequate procedures in place for:**

- Phytosanitary certification? 1 YES 1 NO
- Packaging? 1 YES 1 NO
- Shipping? 1 YES 1 NO
- Other, please specify: (_____) 1 YES 1 NO

**12.7 Do you keep records of the finger millet accession distribution?**
1 YES 1 NO
*(e.g. who received it, quantity, date of shipment, nature of distributed material etc.)*

**12.8 Please indicate the proportion (in %) of users who received finger millet germplasm from you in the past 3 years:**

| Type of users: | Proportion of total distribution % |
|---|---|
| Farmers and Farmers' organisations | |
| Other genebank curators | |
| Academic researchers and students | |

| | |
|---|---|
| Domestic users | |
| Foreign users | |
| Plant breeders - public sector | |
| Plant breeders - private sector | |
| NGOs | |
| Others, please specify: | |

**12.9 Describe briefly how you inform potential users about the availability of finger millet accessions and their respective data in your collection?**

| |
|---|
| |
| |
| |
| |
| |

**12.10 Describe briefly what are the most important factors limiting the use of the finger millet material maintained in your collection?**

| |
|---|
| |
| |
| |
| |

**12.11 Indicate if users have to pay money or not when they request material from you:**

For accessions: 1 free 1 cost (in US$/accession): _____
For the shipment: 1 free 1 cost (in US$/accession): _____

**12.12 Do you use a <u>Material Transfer Agreement</u> when distributing material?**

1 YES 1 NO

**12.13 Do you have any restrictions on who can receive finger millet materials?**

**1** YES 1 NO

**12.13.1 If YES, please specify:**

_____

**<u>13. Networks of finger millet genetic resources</u>**

**13.1 Do you collaborate in (a) network(s) as a finger millet collection holder?**
1 YES 1 NO

**13.2 If you collaborate in (a) network(s) please provide the following information of them:**

*(A) name, (B) type (national, regional or worldwide), (C) main objectives, and (D) a brief description of the main reasons to participate in the network.*

| **A**<br>**Name of network** | **B**<br>**Type of network**<br>National/Regional/Worldwide | **C**<br>**Main objectives of the network** | **D**<br>**Brief description of the main reasons to participate in the network** |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

**14. Additional crop collections maintained in your institute: please indicate additional crops and number of accessions in the table below:**

| | **Crop or species** | **Number of accessions** | **% of wild relative species** |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |
| 10 | | | |
| 11 | | | |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| 18 | | | |

**15. Major constraints: Please list the 5 major limitations you are facing in the management of the finger millet collection:**

| |
|---|
| 1) |
| 2) |
| 3) |
| 4) |
| 5) |

**16. Question concerning institutes NOT maintaining finger millet *ex situ* collections**

**16.1 If your institute does not maintain an *ex situ* collection of finger millet, please indicate to the best of your knowledge, the following:**

| | |
|---|---|
| **Current finger millet conservation activities:** | |
| **Institute focal person to contact for further details:** | |
| **Plans for any finger millet *ex situ* conservation:** | |
| **Any other information:** | |

| **17. Please add any further comments you may have:** |
|---|
| |
| |
| |
| |

**Thank you for your important contribution!!!**

Please return this questionnaire, no later than Friday 27 August 2010 to:

**The South Asia Coordinator**
**Dr. Prem Narain Mathur**
Bioversity International, Sub-regional Office for
South Asia
NASC Complex
Pusa Campus, New Delhi 110012, India
Tel: +91-11-25849000/01 Fax: +91-11-25849002
Email: p.mathur@cgiar.org

**APPENDIX 2: Institutes/persons invited to participate in the survey questionnaire**

| Country | Institute name | Contact person | Address | Email address | Response received<br><br>Yes/No |
|---|---|---|---|---|---|
| Australia | Australian Tropical Grains Germplasm Centre<br>Crop and Food Science,<br>Agri-Science Queensland | Dr Sally Norton | LMB 1, Biloela QLD 4715 | sally.norton@deedi.qld.gov.au | Yes |
| Austria | Austrian Agency for Health and Food Safety<br>Institute for Potato Plant Material & Plant Genetic Resources | Dipl.-Ing. Paul Freudenthaler | Wieningerstraße 8<br>A-4020 LINZ, Austria | paul.freudenthaler@ages.at | Yes |
| Azerbaijan | National PGR Inventory Focal Point | Afig Mammadov | Genetic Resources Institute of ANAS<br>155, Azadlig ave.,<br>AZ1106, Baku, Azerbaijan | akparov@yahoo.com | Yes |
| Bangladesh | | Dr. Mhd. Khaled Sultan | Bangladesh | sultankbari_2010@yahoo.com | No |
| Bhutan | National Biodiversity Centre | Ms. Asta Tamang | Serbithang, thimphu | astapgrfa@yahoo.com | Yes |
| Bulgaria | | Dr. Siyka Stoyanova | Bulgaria | s_stoyanova@gbg.bg | No |
| Burkina Faso | | Dr. Roger Zangre | Burkina Faso | balma_didier@yahoo.fr | No |
| Burundi | Institut des Sciences Agronomiques du Burundi | Mr. Baramburiye Juvent | Avenue de la Cathédrale, Bujumbura, Postal code: 795, Burundi | juventbaramburiye@yahoo.fr | Yes |

| | | | | | |
|---|---|---|---|---|---|
| China | Lu ping | Mr. Tian Jing | No.12 Zhongguancunnandajie, Haidianqu, Beijing 100081 | zaliang@sina.com | Yes |
| Czech Republic | Crop Research Institute | Iva Faberova | Drnovska 507<br>161 06 Praha 6 - Ruzyne | faberova@vurv.cz | No |
| Eritrea | National Agricultural Research Institute (NARI) | Mr. Amanuel Mahdere | Asmara, Postal code: 4627, Eritrea | amanuelmaz@yahoo.com | Yes |
| Ethiopia | | Dr. Kassahun Embaye | Ethiopia | ddg@ibc-et.org, | No |
| Germany | Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) | Dr. Ulrike Lohwasser | Gatersleben, D-06466, Germany | lohwasse@ipkgatersleben.de | Yes |
| Hungary | Research Centre for Agrobiodiversity | Attila Simon | Tápiószele<br>Külsőmező 15.<br>H-2766<br>(Hungary) | jensen@agrobot.rcat.hu | Yes |
| ICRISAT, India | International crops Research Institute for the Semi-Arid Tropics | Dr. Hari D Upadhaya | Patancheru 502324, Hyderabad | h.upadhyaya@cgiar.org | Yes |
| NBPGR, India | National bureau of Plant genetic Resources | Dr. KC Bansal | NBPGR, New Delhi - 110012 | director@nbpgr.ernet.in | Yes |
| Indonesia | Indonesia Centre Of Agricultural Biotechnology and genetic Research Development | Dr. Azrai | JI. Tentara Pelajar No.3A, Bogor, 16111, Indonesia | azraimuh@yahoo.com | Yes |
| Italy | | Marisa Scarascia | Italy | marisa.scarascia@igv.cnr.it | Yes |
| Kenya | Kenya Agricultural Research Institute, The National Genebank of | Dr. Ndungu Kimani | P.O. Box 30148, Nairobi 00100, Kenya | kenya.genebank@gmail.com; ngbk@wananchi.com | Yes |

| | | | | | |
|---|---|---|---|---|---|
| | Kenya | | | | |
| Lesotho | Ministry of Agriculture, Department of Agricultural Research, | Christina Mohloboli Maleoa | PO. Box 829, MASERU 100, Lesotho | maleoacm@yahoo.co.uk | Yes |
| Madagascar | | Dr. Alain Ramanantsoanirina | Madagascar | ntsoaniri@yahoo.com | No |
| Malawi | Malawi Plant Genetic Resources Centre | Lawrent Pungulani | Chitedze Research Station, P.O. Box 158, Lilongwe | genebank@malawi.net / lawrentp@yahoo.co.uk | Yes |
| Mozambique | Instituto de Investigação Agrária de Moçambique (IIAM) | Barnabas Kapange | Av. Das F.P.L.M. 2698, , Maputo, 3658 | bkapange@gmail.com | Yes |
| Myanmar | Biotechnology, Plant genetic resources and Plant protection Centre | Daw Kin San Wei | Myanmar | ksw.dar@gmail.com | Yes |
| Namibia | | Remmie Moses | Namibia | mosesr@nbri.org.na | Yes |
| Nepal | National Agriculture Genetic Resources Centre (NAGRC) | Dr. Madan Bhatta | Khumaltar, Lalitpur, Nepal | madan_bhatta@yahoo.com | Yes |
| Niger | | | Niger | | |
| Poland | National Centre for Plant Genetic Resources | Marcin Zaczyński | Poland | m.zaczynski@ihar.edu.pl | Yes |
| Russian Federation | N.I. Vavilov Research Institute of Plant Industry (VIR) | Sergey Shuvalov | 42-44, B.Morskaya Street, St.Petersburg, 190000, Russia | s.shuvalov@vir.nw.ru | Yes |
| Rwanda | | R Jean Gapusi | Rwanda | gapusirj@yahoo.fr | Yes |
| Sri Lanka | Plant Genetic Resources Centre | Dr. Ratnasiri | P.O. Box 59, Gannoruwa, Peradeniya, 20400 | pgrc@slt.lk | Yes |

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|---|---|---|---|---|---|
| Sudan | | Dr. Eltahir Mohamed | Sudan | eltahir@sudanmail.net.sd; elthahir81@yahoo.com | No |
| South Africa | National Plant Genetic Resources centre | Mr. Thabo Tjikana | Department of Agriculture, Forestry and Fisheries, private Bag X 973, Pretoria 0001 | ThaboTj@daff.gov.za | No |
| Tanzania | National Plant Genetic Resources Centre | Margaret Mollel | P.O Box 3024<br>Arusha, Tanzania | mjk_mollel@yahoo.com | Yes |
| Ukraine | National Centre for Plant Genetic Resources of Ukraine | Victor Ryabchoun Ph.D | Kharkiv, Ukraine | boguslavr@rambler.ru | Yes |
| United Kingdom, Kew | Millennium Seed Bank | Mr. Janet Terry | Royal Botanic Gardens Kew, Ardingly, RH17 6TN | j.terry@kew.org | Yes |
| USA | Centro Internacional de Agricultura Tropical (CIAT) | Libreros, Dimary | Apartado Aereo 6713, Cali, Colombia | d.libreros@CGIAR.ORG | Yes |
| USA, IOWA | Plant Introduction Station phone 515-294-6786<br>Iowa State University | David Brenner | Ames, IA 50011-1170<br>USA | David.Brenner@ARS.USDA.GOV | Yes |
| Vietnam | Plant Resources Centre, Vietnam Academy of Agricultural Sciences | La Tuan Nghia | An Khanh, Hoai Duc, ha Noi | thuhoai70@yahoo.com | Yes |
| Zambia | National Plant Genetic Resources Centre | Dickson Ng'uni | Zambia Agriculture Research Institute, P/Bag 7, Chilanga, Zambia | Dickson.nguni@gmail.com | Yes |

**APPENDIX 3: List of participants of "Global strategies for the *ex situ* conservation of finger millet and their wild relatives" held at the National Bureau of Plant Genetic Resources, New Delhi on 23 December 2011**

| | Country | Participant | Email |
|---|---|---|---|
| 1 | India | Dr. Hari D Upadhyaya<br>Assistant Research Program Director,<br>Grain Legumes and Principal Scientist and Head of Gene Bank,<br>International Crops Research Institute for the Semi Arid Tropics (ICRISAT),<br>Patancheru 502 324, Andhra Pradesh, India | h.upadhyaya@cgiar.org |
| 2 | India | Dr. MVC Gowda<br>Project Coordinator,<br>All India Coordinated Research Project on Small Millets, University of Agricultural Sciences, Bangalore, India | mvcgowda@sify.com ;<br>smallmillets@gmail.com |
| 3 | India | Dr. A Seetharam<br>ex-Project Coordinator,<br>All India Coordinated Research Project on Small Millets, University of Agricultural Sciences, Bangalore, India | annadanasram@rediffmail.com |
| 4 | India | Dr. C Tara Satyavathi<br>Principal Scientist,<br>Division of Genetics, Indian Agricultural Research Institute, Pusa Campus,<br>New Delhi - 110 012, India | csatyavathi@yahoo.co.in |
| 5 | India | Dr. RK Tyagi<br>Principal Scientist and Head,<br>Germplasm Conservation Division,<br>National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi 110012, India | rktyagi@nbpgr.ernet.in |
| 6 | India | Dr. DC Bhandari<br>Principal Scientist and Head,<br>Germplasm Exploration Division,<br>National Bureau for Plant Genetic Resources,<br>Pusa Campus, New Delhi 110012 | bhandaridc@nbpgr.ernet.in |
| 7 | India | Dr. M Dutta<br>Principal Scientist and Head,<br>Germplasm Evaluation Division, National Bureau of Plant Genetic Resources,<br>Pusa Campus, New Delhi 110012, India | mdutta@nbpgr.ernet.in |

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|---|---|---|---|
| 8 | Uganda | Dr. Nelson Wanyera<br>Millet Breeder,<br>NARO, Uganda | nwanyera@hotmail.com |
| 9 | Kenya | Dr. Chrispus Oduori<br>Principal Research Officer,<br>National Co-ordinator, Millets Research, and head Sorghum and Millet Research,<br>KARI-Kakamega, P.O. Box 169,<br>Kakamega, Kenya | chrisoduori@yahoo.com |
| 10 | Mali | Mr. Amadou Sidibe<br>Head of Genetic Resources,<br>Institute of Rural Economy, URG/IER<br>BP. 258 Avenue Mohamed V, Bamako,<br>Mali | Amadou.sidibe19@gmail.com |
| 11 | Senegal | Mr. Ousmane Sy<br>Millet Breeder,<br>BP 53 ISRA/Bambey, Senegal | oussousyso@yahoo.fr |
| 12 | Kenya | Dr. Desterio Ondieki Nyamongo<br>National Coordinator, Genetic Resources Conservation<br>Kenya Agricultural Research Institute,<br>National Genebank of Kenya,<br>P.O. Box 30148<br>00100 Nairobi, Kenya | dnyamongo@yahoo.co.uk |
| 13 | India | Dr. Bhuwon Sthapit<br>Regional Project Coordinator,<br>Bioversity International, Office for South Asia, NASC Complex,<br>New Delhi 110012, India | b.sthapit@cgiar.org |
| 14 | India | Dr. Hugo Lamers<br>Associate Scientist,<br>Bioversity International, Office for South Asia, NASC Complex,<br>New Delhi 110012, India | h.lamers@cgiar.org |
| 15 | India | Dr. Prem Narain Mathur<br>South Asia Coordinator,<br>Bioversity International, Office for South Asia, NASC Complex,<br>New Delhi 110012, India | p.mathur@cgiar.org |
| 16 | India | Dr. Sushil Pandey<br>Senior Scientist,<br>Millet Curator, Division of Germplasm Conservation, National Bureau of Plant Genetic Resources,<br>New Delhi-110 012, India | sushil_pandey@nbpgr.ernet.in |
| 17 | India | Dr. KC Bhatt<br>Senior Scientist,<br>Plant Exploration and Collection Division, | kcbhattps@yahoo.com |

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|---|---|---|---|
| | | National Bureau of Plant Genetic Resources,<br>New Delhi-110 012, India | |
| 18 | India | Dr. Jyoti Kumari<br>Senior Scientist,<br>Germplasm Evaluation Division, National Bureau of Plant Genetic Resources,<br>New Delhi-110 012, India | jyoti@nbpgr.ernet.in |
| 19 | India | Dr. Nidhi Verma<br>Senior Scientist,<br>Germplasm Exchange Unit, National Bureau of Plant Genetic Resources,<br>New Delhi-110 012,India | nidhipgr@gmail.com |
| 20 | India | Ms. Sarika Mittra<br>Scientific Assistant (GIS Consultant),<br>Bioversity International, Office for South Asia, NASC Complex,<br>New Delhi 110012, India | s.mittra@cgiar.org |

**APPENDIX 4: Agenda for the workshop on "Global strategies for the *ex situ* conservation of finger millet and their wild relatives" held at the National Bureau of Plant Genetic Resources, New Delhi on 23 December 2011**

**Objective:**

To consult representatives of relevant finger millet collections on key elements of global strategies for the efficient and effective *ex situ* conservation of the genetic resources.

**Expected outcomes**:

1. Key global, regional and national collections of finger millet genetic resources identified;
2. Critical overlaps and gaps in existing collections identified;
3. Major needs and opportunities for upgrading key collections and building the capacity managers to maintain and distribute them efficiently and effectively over the long term identified, and
4. Recommendations for increased collaboration and sharing of responsibilities, leading to more effective and efficient conservation and greater utilization finalized.

**Programme:**

09:00 – 12:00: ***Session I: Overview of the draft strategy for finger millet – Prem Mathur***

- Origin, domestication and taxonomic history
- Overview of finger millet collections
- Characterization, evaluation, seed distribution and utilization status
- Conservation status, including safety duplication and regeneration needs
- Distribution and gaps in finger millet collection
- Distribution of *Eleusine* species and gap analysis
- Documentation status
- Limitation in the management and use
- Training needs for efficient management and use of finger millet genetic resources
- Recommendations

(10.30 to 11.00: ***Tea/Coffee break***)

12.00 – 13.00 Visit to NBPGR facilities

13:00 – 14:00 ***Lunch***

14:00 – 16:30 ***Session II: Group discussions:***
Working groups meet in parallel sessions to consider items 1-12 in the Appendix to this agenda.

15.15 to 15.30: ***Tea/Coffee break***

16.30 – 17.00 ***Session III: Plenary session for working groups to report back and raise any issues and concerns***

17.00 – 17.30 ***Session IV: Closing***

**APPENDIX 5: Topics to be discussed in parallel group sessions for finger millet**

1. Review and verify the data presented on the various collections and to identify:
   - Any additional collections to be included
   - Any collections that should be dropped from the table
   - Major items of missing data and how they can be filled
2. Consider the proposed criteria for a reference collection, i.e.:
   - Collections on which the world depends
   - Substantial size and diversity
   - Generally international or regional in coverage
   - Secure - managed to international standards - and in general adequately funded
   - Readily available on request under terms of International Treaty on PGRFA
   - Identify the main collections that meet these criteria.
3. Identify other significant collections, and sets of accessions within collections, taking into account criteria such as:
   - Collection size and diversity (number and origin of accessions)
   - Uniqueness of the material
   - Type of material (landraces, released cvs., wild spp. genetic stocks, etc)

(Where possible, indicate the major support needs of any such collections identified)

4. Identify potential partners who are able to provide conservation services such as: characterizing or evaluating material for key characters, indexing for diseases, providing specialized assistance with regeneration or storage, providing information or germplasm distribution services, etc.
5. Identify major gaps in the total genetic diversity coverage of existing collections
6. Assess the current status of data and information systems and indicate how they could be strengthened and the data made more accessible.
7. To what extent are collections already duplicated for safety and how can the situation be improved? What standards/guidelines should apply (consider both second-country safety duplication and duplication at the Svalbard International Seed Vault.
8. What are the major policy and technical impediments to a greater distribution of materials (e.g. with respect to seed quantity, seed quality, quarantine/ phytosanitary arrangements, a clear policy on distribution, agreed MTA etc.), and how can they best be overcome?
9. Identify and assess the effectiveness of any networks and international cooperative programmes that exist for the crop in question. How can collaboration best be strengthened?
10. Assess the effectiveness of links to users (plant breeders and farmers). How can a greater use of the genetic materials best be promoted?
11. What are the most important training needs and how might they best be addressed?
12. Identify key next steps in further development of the strategy and its implementation.

## APPENDIX 6: List of acronyms

| | |
|---|---|
| AGES | Austrian Agency for Health and Food Safety |
| AICRP | All India Coordinated Project |
| AICRP-FC | All India Coordinated Project for Research on Forage Crops |
| AICSMIP | All Indian Coordinated Small Millets Improvement Project |
| AISMIP | All India Small Millets Improvement Programme |
| APAARI | Asia Pacific Association of Agricultural Research Institutions |
| CBD | Convention on Biological Diversity |
| CGIAR | Consultative Group for International Agricultural Research |
| CLAN | Cereal Legumes Asian Network |
| EURISCO | European Plant Genetic Resources Search Catalogue |
| FAO | Food and Agriculture Organization of the United Nations |
| GBIF | Global Biodiversity Information Facility |
| GCDT | Global Crop Diversity Trust |
| IARC | International Agricultural Research Centres |
| ICAR | Indian Council of Agricultural Research |
| ICRISAT | International Crops Research Institute for the Semi-Arid Tropics |
| IDMRS | ICRISAT Data Management and Retrieval System |
| IPK | Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), (Germany) |
| ITPGRFA | International Treaty on Plant Genetic Resources for Food and Agriculture |
| NAGS | National Active Germplasm Site |
| NARC | Nepal Agricultural Research Council |
| NARS | National Agricultural Research Systems |
| NBPGR | National Bureau of Plant Genetic Resources (India) |
| NPGRC | National Plant Genetic Resources Center (Mozambique) |
| PGRC | Plant Gene Resources of Canada |
| SADC | South African Development Community |
| SDIS | SADC Documentation and Information System |
| SGRP | System-wide Genetic Resources Program |
| SGSV | Svalbard Global Seed Vault |
| SINGER | System-wide Information Network for Genetic Resources |
| SMTA | Standard Material Transfer Agreement |
| SoW | First State of the World's Plant Genetic Resources for Food and Agriculture Report |
| SPGRC | South African Development Community (SADC) Plant Genetic Resources Centre |
| USDA | United States Department of Agriculture |
| VIR | N.I. Vavilov Research Institute of Plant Industry (Russian Federation) |
| WIEWS | World Information and Early Warning System |